

DOCUMENT RESUME

ED 336 599

CE 058 992

TITLE Construction Techniques. Drafting Module 2.
Instructor's Guide.

INSTITUTION Missouri Univ., Columbia. Instructional Materials
Lab.

SPONS AGENCY Missouri State Dept. of Elementary and Secondary
Education, Jefferson City. Div. of Vocational and
Adult Education.

PUB DATE 91

NOTE 195p.; For related documents, see CE 058 991-998.
Modules 7-8 have not yet been developed.

AVAILABLE FROM Instructional Materials Laboratory, University of
Missouri, 2316 Industrial Drive, Columbia, MO 65202
(order no. 70-4002-I: \$23.75).

PUB TYPE Guides - Classroom Use - Teaching Guides (For
Teacher) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.

DESCRIPTORS *Competency Based Education; *Drafting; *Freehand
Drawing; *Geometric Constructions; High Schools;
Layout (Publications); Teaching Guides; Vocational
Education

IDENTIFIERS Missouri; Sketching

ABSTRACT

This Missouri Vocational Instruction Management System instructor's drafting guide has been keyed to the drafting competency profile developed by state industry and education professionals. The guide contains a cross-reference table of instructional materials. Four units cover construction techniques: (1) drawing sheet layout; (2) sketching; (3) lettering; and (4) geometric constructions. Each unit contains the following: (1) unit and specific objectives; (2) suggested activities; (3) instructional materials; (4) unit content; (5) references; (6) instructor notes; (7) information sheets; (8) lessons; (9) transparency masters; (10) handouts; (11) assignment sheets; (12) job sheets; and (13) unit test and answers. (NLA)

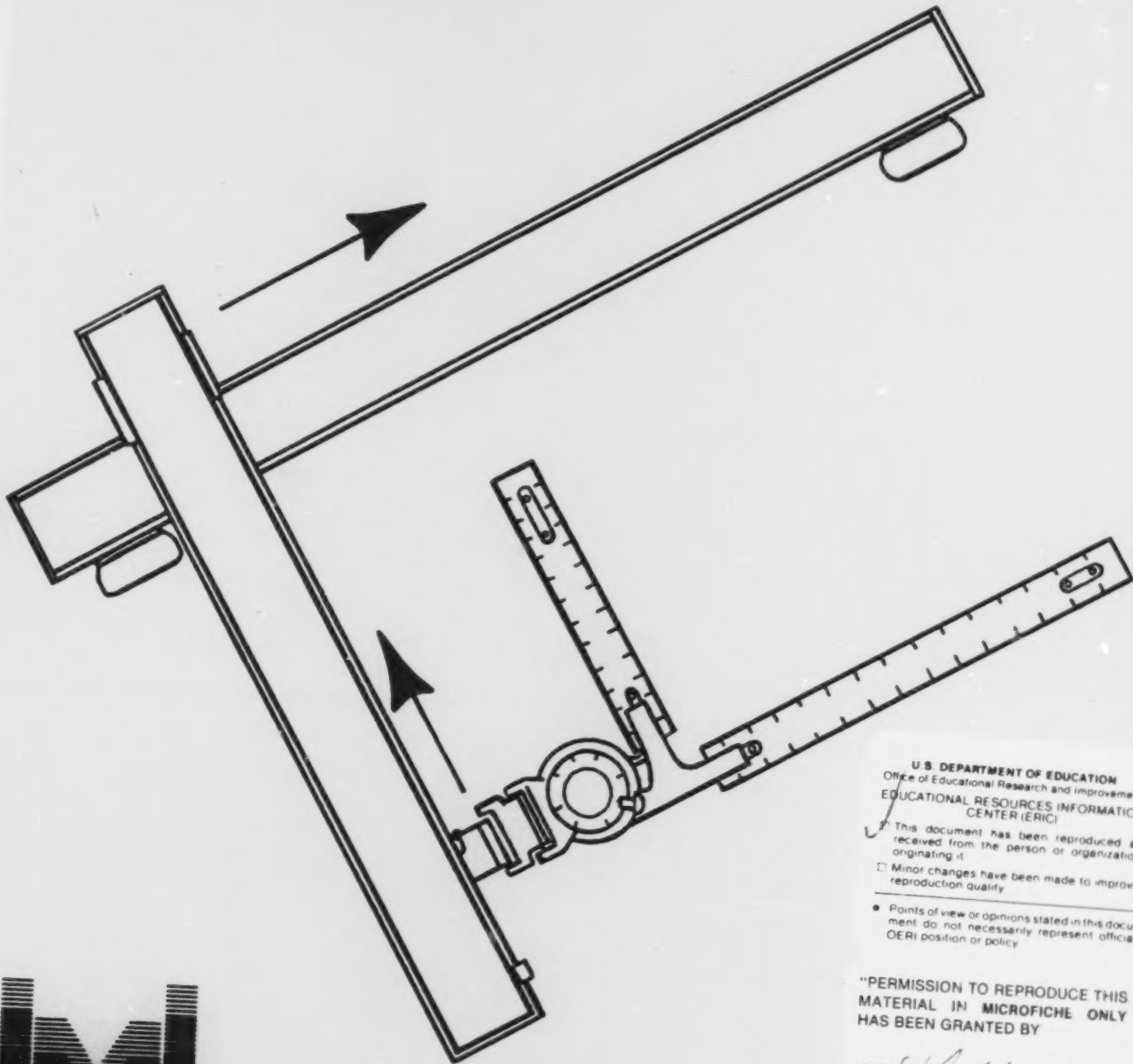
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Module

2 CONSTRUCTION TECHNIQUES

70-4002-1
Instructor's Guide

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DRAFTING

Module 2: Construction Techniques

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1991

Instructor's Guide
Catalog N. 70-4002-I

FORWARD

Once again, we are indebted to the teachers and administrators who provided their time, effort and professionalism to develop curriculum guides for trade, technical and industrial education programs. This drafting guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource—it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignments sheets and test items are keyed to specific competencies. A cross-reference table has been included to identify quickly the parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future drafting curriculum modifications will begin with this guide. The drafting field is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, supervisor
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ACKNOWLEDGEMENTS

This drafting guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the drafting competency profile developed by industry and education professionals in the state.

When searching for current drafting materials to adopt or use in the guide's development, comparable materials were found from the Mid-America Vocational Curriculum Consortium (MAVCC), of which Missouri is a member. MAVCC materials, therefore, have been relied upon as a resource for this guide. A debt of thanks is owed to the entire MAVCC organization for the research and development of these drafting materials.

Special appreciation is given to the writers for their self-motivation, reliability and technical expertise.

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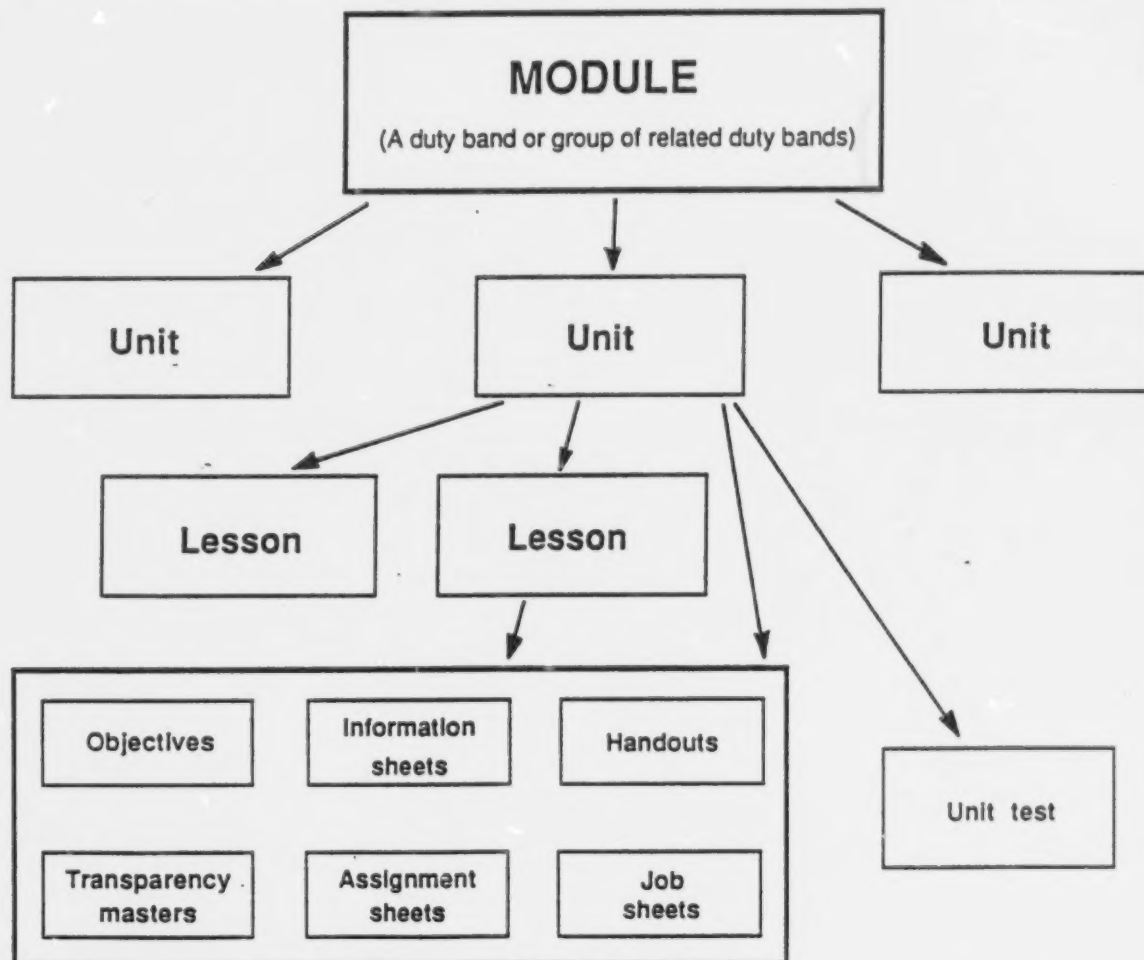
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HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of instruction

This Drafting guide contains ten modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc., are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

- 3 = **Mastery** - can work independently with no supervision
- 2 = **Requires supervision** - can perform job completely with limited supervision
- 1 = **Not mastered** - requires instruction and close supervision
- N = **No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, etc. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives that state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc., are included in the Notes to the Instructor section.

Information sheets (color-coded green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage, while **WARNING** statements recommend procedures to avoid bodily injury. Handouts and transparency masters are noted in the information sheets for instructional use.

Transparency masters (color-coded white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary, and they direct students to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion.

Handouts (color-coded white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (color-coded tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (color-coded blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance that might be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (color-coded yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), using Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson by lesson.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

Drafting

Module: Construction Techniques

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
C-1	I	1.1-1.3	1				1-18	
C-2	I	1.4-1.7	2-5		1		19-66	
C-3	II	1.1-1.13	1-5		1-5		1-44	
C-4	III	1.9	4				21-27	
C-5	III	1.1-1.13 1.17-1.21	7-12		1, 7-12		1-35 42-62	
C-6	II	1.6, 1.12	1		1		1-44	
C-7	III	1.14-1.16 1.21	2-6		2, 3, 8		36-41	
C-8	II	1.13			1-5		1-44	
C-9	II	1.13			1-5		1-44	
C-10								
D-1	IV	1.1-1.11	1-4		1, 2		1-110	
D-2	IV	1.1-1.11	5-7; 14, 15		3, 6, 7, 8		1-110	
D-3	IV	1.1-1.11	1-15		9, 10, 11, 12		1-110	
D-5	IV	1.1-1.11			13		1-110	

MODULE: CONSTRUCTION TECHNIQUES

UNIT I: DRAWING SHEET LAYOUT

UNIT OBJECTIVE

After completion of this unit, the student should be able to match types of drawings and terms related to a drawing sheet layout with their correct definitions. The student should also be able to select the items in working drawings that are checked for accuracy. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment sheet and by scoring ___ percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

- 1.1 Match terms related to a drawing sheet layout with their correct definitions.
- 1.2 Match types of working drawings with their correct definitions.
- 1.3 Match other types of drawings with their correct definitions.
- 1.4 Select information found in a title block.
- 1.5 Select information found in a revision block.
- 1.6 Select information found in a parts list.
- 1.7 Select information found in supplementary blocks.

CONTENTS OF THIS UNIT

- A. Objective sheet
- B. References
- C. Notes to the instructor
- D. Lesson plans
 - 1. Lesson 1: WORKING DRAWINGS AND INFORMATION BLOCKS
 - a. Information outline
 - b. Transparency masters
 - TM 1.1: Sheet Sizes
 - TM 1.2: Parts List
 - TM 1.3: Title Blocks
 - TM 1.4: Title Blocks (Continued)
 - TM 1.5: Revision Blocks
 - c. Assignment sheet
 - AS 1.1: Complete a Title Block Sheet
- E. Test
- F. Answers to test

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NOTES TO THE INSTRUCTOR

Suggested approaches to teaching this unit

1. Use file drawings to demonstrate to the class the location of various information blocks and areas on a set of working drawings.
2. Invite a checker from a local drafting or architectural firm to speak to the class concerning techniques used in checking drawings.
3. Using information from various companies, have students complete several title blocks.

MODULE: CONSTRUCTION TECHNIQUES

UNIT I: DRAWING SHEET LAYOUT

LESSON 1: WORKING DRAWINGS AND INFORMATION BLOCKS

I. Terms and definitions

- A. **Change order**--an approved engineering change on an existing drawing
- B. **Drawing**--graphic and lettered information on an original media surface
NOTE: A drawing is sometimes referred to as a plate.
- C. **Drawing number**--should be located in the lower right corner of the title block and in at least one other location
- D. **Parts list** (list of materials or bill of materials)--should be located in the lower right corner above the title block (TM 1.2)

NOTE: If additional parts listed are needed they should be located left of or adjacent to the original parts list.

- E. **Revision**--a correction made on a drawing to reflect a needed change
- F. **Revision block**--should be located in the upper right corner of the drawing layout
NOTE: Some companies may move the location.
- G. **Supplementary block**--should be located in the same respective location on all drawings, usually to the left of the title block
- H. **Title block**--should be located in the lower right corner of the drawing layout
NOTE: Some companies may move the location.

- I. **Zones**--the areas on the border of a drawing sheet used for locating specific points by the coordinate point system (TM 1.1)

NOTE: On a complicated drawing, if there is a revision to be made which would be difficult to locate, use zones to determine the revision quickly and accurately.

II. Types of working drawings and their definitions

- A. **Assembly drawing**--a description of how several subassemblies and details make up a larger unit
- B. **Detail drawing**--the complete size, material, and specification description of an individual part

- C. **Installation drawing**—a description of how an object fits into its working position
- D. **Set of working drawings**—a number of working drawings bound together to do a complete project or job
- E. **Subassembly drawing**—a description of how several parts fit together in one unit
- F. **Working drawing**—a drawing needed to manufacture, build, assemble, or install any unit, component, or structure

NOTE: The drawing must have size and shape descriptions, specifications for the materials to be used, the finish, and completeness of the project.

III. Other types of drawings and their definitions

- A. **Checking drawings or check set**—drawings which are carefully checked for accuracy before they are sent into the field or into the shop for fabrication

NOTE: Checking should be done by a drafter who is not working on the drawing, or by the project engineer or architect, chief drafter, or the checker, depending on the company structure.

- B. **Layout drawings**—drawings used in the development of experimental or prototype designs

NOTE: They appear to be assembly drawings; however, layout drawings are used in the early developmental stages of a product and assembly drawings are for the final fabrication process.

- C. **Process drawings**—drawings of only one step in a production or manufacturing assembly which enable a machine operator to set up equipment for a single operation

Examples: drilling, punching holes, milling a surface

IV. Information found in a title block (TM 1.3 and 1.4)

- A. Company name and address or manufacturer's (code identification) number

NOTE: The manufacturer's number may be referred to as the FSCM. This stands for the Federal Supply Code for Manufacturers.

- B. Drawing (plate) name
- C. Drawing (plate) number
- D. Drafter's name
- E. Date drafter completed drawing
- F. Checker's name
- G. Date checker completed checking functions
- H. Approval signatures
- I. Issue date

- J. Contract numbers
- K. Approval by someone in another company

NOTE: Used only when a contractor-subcontractor situation exists.

- L. Scale
- M. Letter designation of drawing size if necessary
- N. Estimated or actual weight of the item

NOTE: This may not be required.

- O. Drawing sheet number

NOTE: This is included only if needed.

V. Information found in a revision block (TM 1.5)

- A. Revision number
- B. Description or identification
- C. Date
- D. Approval
- E. Zone

NOTE: The zone may not be needed.

- F. Reason for revision

NOTE: This may not be necessary.

VI. Information found in a parts list (TM 1.2)

- A. Writer's name
- B. Approval signature
- C. Checker's name
- D. Date
- E. Assembly list number
- F. Description of the assembly
- G. Page number of the total parts lists
- H. Account number if needed for billing purposes
- I. Name of item

- J. Item number of subassembly
- K. Quantity needed
- L. Description of subassembly
- M. Part number of subassembly
- N. Letter designation of drawing size

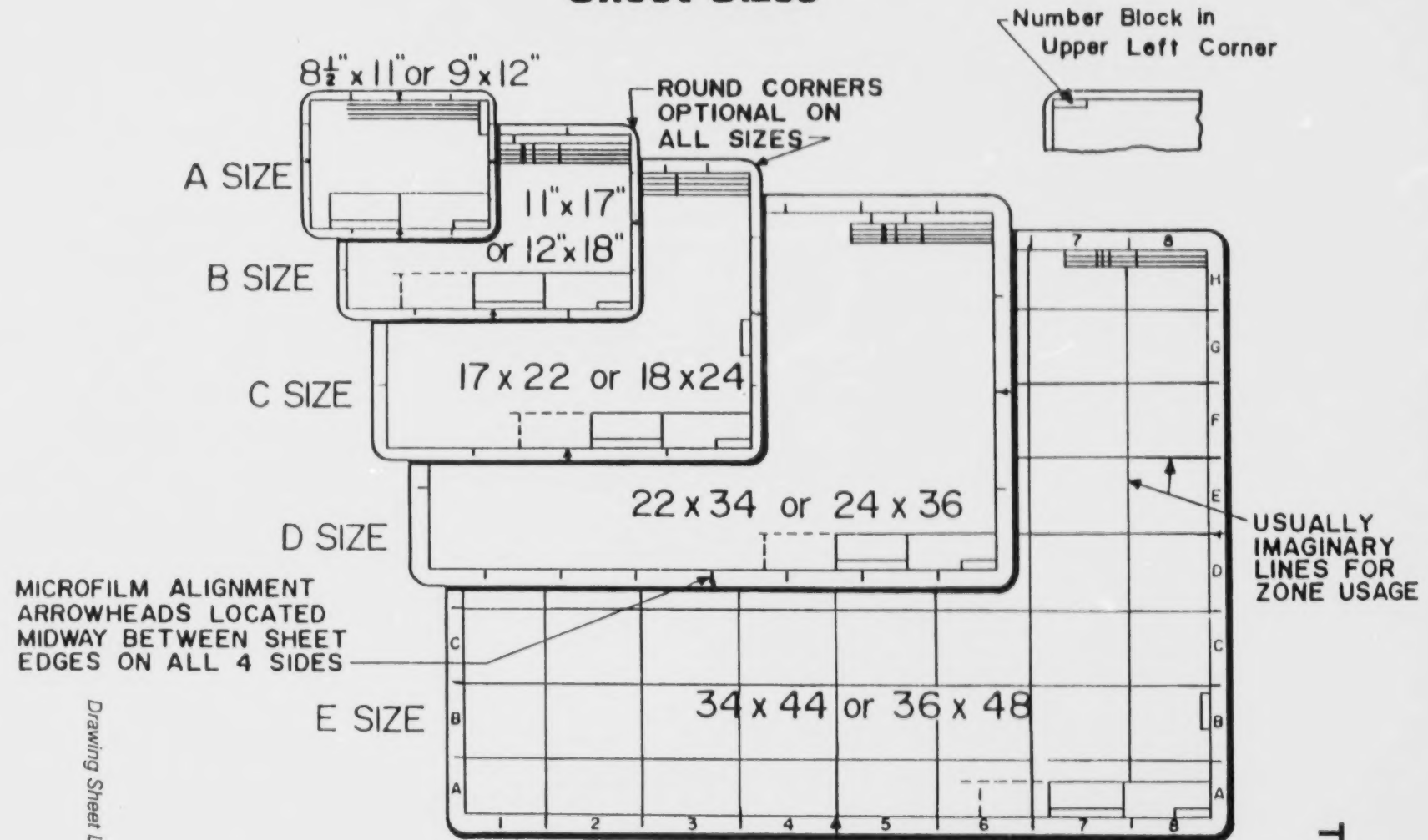
NOTE: This may not be necessary.

- O. Name and other information about the vendor if part is purchased from another company

VII. Information found in supplementary blocks

- A. Information covering notes on dimensioning and tolerances
- B. Material
- C. Usage and general notes
- D. Treatment
- E. Finish

Sheet Sizes



Drawing Sheet Layout

TM 1.1

Parts List

[illegible]

Drawing Sheet Layout

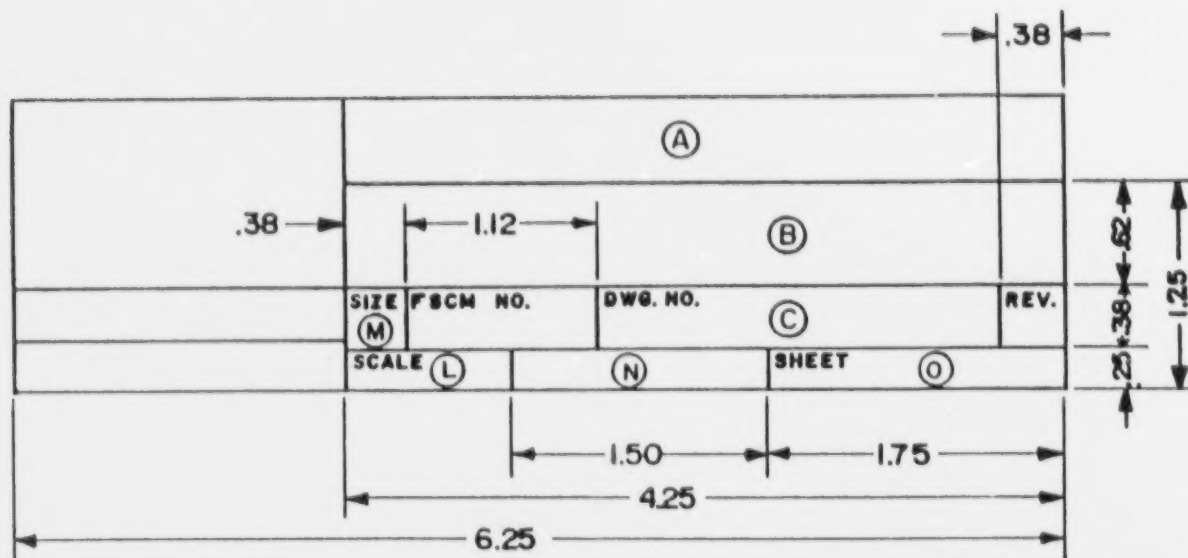
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10

TM 1.2

20

Title Blocks

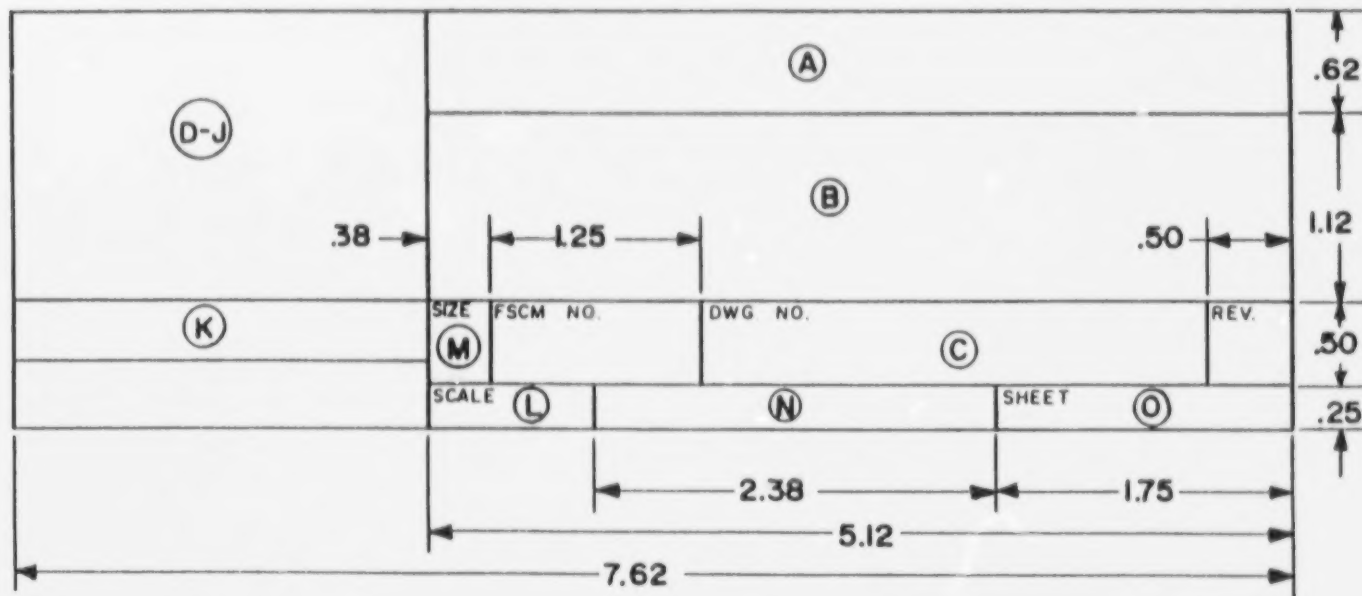


TITLE BLOCK FOR A, B, AND C SIZES

NOTE: ALL DIMENSIONS ARE IN INCHES.

Title Blocks

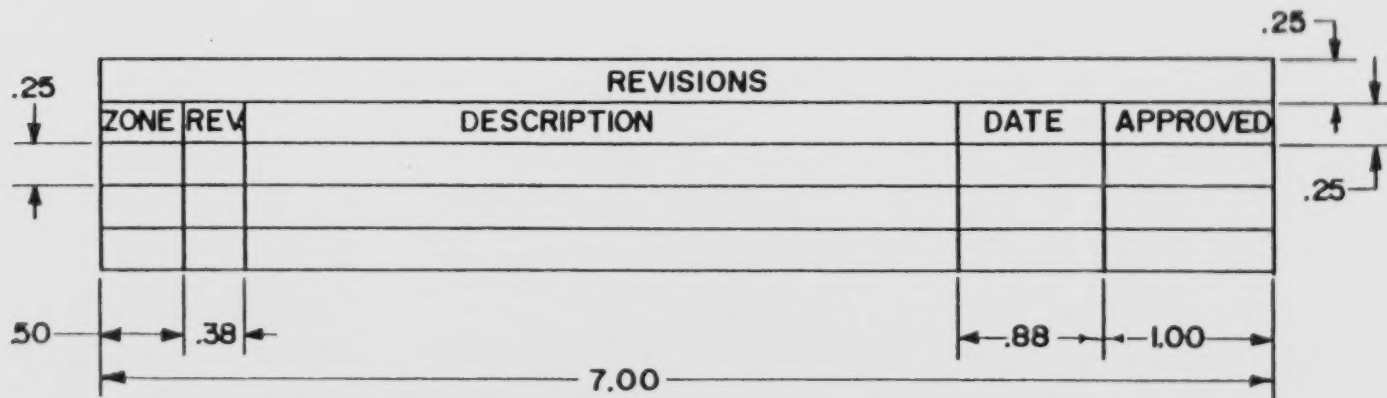
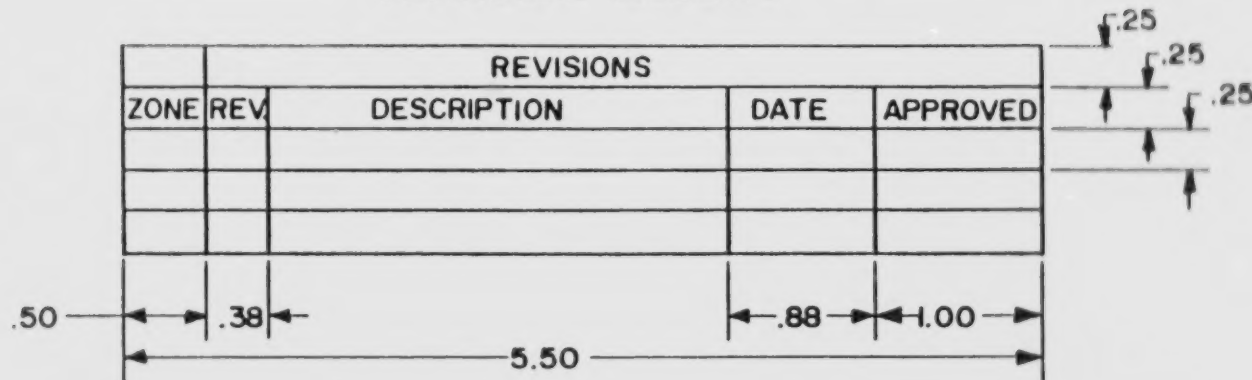
(Continued)



TITLE BLOCK FOR D, E, F, H, J, AND K, SIZES

NOTE: ALL DIMENSIONS ARE IN INCHES.

Revision Blocks



NOTE: ALL DIMENSIONS ARE IN INCHES

COMPLETE A TITLE BLOCK SHEET

- I. Tools and equipment
 - A. Pencil
 - B. Drawing sheet
 - C. Parallel bar or drafting machine
- II. Procedure
 - A. Tape sheet to drawing surface
 - B. Select correct pencil
 - C. Compile title block data
 - D. Letter in information in its proper place
- III. Diagram of the procedure

NOTE: Instructor should select an appropriate border and title block to use in this class and give instructions on filling it out.

Pictured on Transparencies 1.3 and 1.4 are samples of title blocks. Devise one of your own or select one shown.

MODULE: CONSTRUCTION TECHNIQUES

UNIT I: DRAWING SHEET LAYOUT

UNIT TEST

Match the terms on the right with their correct definitions on the left.

- | | | | |
|--------|---|-----|------------------------------|
| ___ 1. | Graphic and lettered information on an original media surface | a. | Change order |
| ___ 2. | A correction made on a drawing to reflect a needed change | b. | Drawing |
| ___ 3. | Should be located in the upper right corner of the drawing layout | c. | Zones |
| ___ 4. | Should be located in the same respective location on all drawings, usually to the left of the title block | d. | Drawing number locations |
| ___ 5. | An approved engineering change on an existing drawing | e. | Supplementary block location |
| ___ 6. | Should be located in the lower right corner of the title block and in at least one other location | ab. | Revision |
| ___ 7. | Should be located in the lower right corner above the title block | ac. | Title block location |
| ___ 8. | Should be located in the lower right corner of the drawing layout | ad. | Revision block location |
| ___ 9. | The areas on the border of a drawing sheet used for locating specific points by the coordinate point system | ae. | Parts list |

Match the types of working drawings on the right with the correct definitions on the left

- | | | | |
|-------|---|-----|-------------------------|
| — 10. | The complete size, material, and specification description of an individual part | a. | Subassembly drawing |
| — 11. | A drawing needed to manufacturer, build, assemble, or install any unit, component, or structure | b. | Assembly drawing |
| — 12. | A number of working drawings bound together to do a complete project or job | c. | Set of working drawings |
| — 13. | A description of how an object fits into its working position | d. | Working drawing |
| — 14. | A description of how several subassemblies and details make up a larger unit | e. | Detail drawing |
| — 15. | A description of how several parts fit together in one unit | ab. | Installation drawing |

Match the types of drawing on the right with their correct definitions.

- | | | | |
|-------|--|----|--------------------------------|
| — 16. | Drawings which are carefully checked for accuracy before they are sent into the field or into the shop for fabrication | a. | Process drawings |
| — 17. | Drawings used in the development of experimental or prototype designs | b. | Checking drawings or check set |
| — 18. | Drawings of only one step in a production or manufacturing assembly which enable a machine operator to set up equipment for a single operation | c. | Layout drawings |

Mark an "a" for information that does belong in a title block and a "b" for information that does not belong in a title block.

- ___ 19. Material
- ___ 20. Drawing name
- ___ 21. Drafter's name
- ___ 22. Part number
- ___ 23. Checker's name
- ___ 24. Approval signatures
- ___ 25. Contract numbers
- ___ 26. Approval by someone in another company
- ___ 27. Quantity needed
- ___ 28. Issue date
- ___ 29. Date checker completed checking functions
- ___ 30. Date drafter completed drawing
- ___ 31. Description subassembly
- ___ 32. Drawing number
- ___ 33. Company name and address of manufacturer's number

Mark an "a" for the information that is found in the revision block and a "b" for the information that is not found in the revision block.

- ___ 34. Date
- ___ 35. Tolerance
- ___ 36. Approval
- ___ 37. Zone
- ___ 38. Reason for revision
- ___ 39. Description or identification
- ___ 40. Checker's name
- ___ 41. Revision number
- ___ 42. List of materials

Mark an "a" for information that is found in a parts list and a "b" for information that is not found in a parts list.

- ___ 43. Part number of subassembly
- ___ 44. Quantity needed
- ___ 45. Name of item
- ___ 46. Zone
- ___ 47. Page number of the total parts lists
- ___ 48. Assembly list number
- ___ 49. Tolerance
- ___ 50. Checker's name
- ___ 51. Writer's name
- ___ 52. Approval signature
- ___ 53. Date
- ___ 54. Description of the assembly
- ___ 55. Treatment
- ___ 56. Account number if needed for billing purposes
- ___ 57. Item number of subassembly
- ___ 58. Description of subassembly
- ___ 59. Letter designation of drawing size

Mark an "a" for information that is found in supplementary blocks and a "b" for information that is not found in supplementary blocks.

- ___ 60. Finish
- ___ 61. Treatment
- ___ 62. Quantity needed
- ___ 63. Material
- ___ 64. Information covering notes on dimensioning and tolerances
- ___ 65. Usage and general notes
- ___ 66. Checker's name

ANSWERS TO UNIT I TEST

- | | | |
|--------------|-------------|-------------|
| 1. b (C-1) | 26. a (C-2) | 51. a (C-2) |
| 2. ab (C-1) | 27. b (C-2) | 52. a (C-2) |
| 3. ad (C-1) | 28. a (C-2) | 53. a (C-2) |
| 4. e (C-1) | 29. a (C-2) | 54. a (C-2) |
| 5. a (C-1) | 30. a (C-2) | 55. b (C-2) |
| 6. d (C-1) | 31. b (C-2) | 56. a (C-2) |
| 7. ae (C-1) | 32. a (C-2) | 57. a (C-2) |
| 8. ac (C-1) | 33. a (C-2) | 58. a (C-2) |
| 9. c (C-1) | 34. a (C-2) | 59. a (C-2) |
| 10. e (C-1) | 35. b (C-2) | 60. a (C-2) |
| 11. d (C-1) | 36. a (C-2) | 61. a (C-2) |
| 12. c (C-1) | 37. a (C-2) | 62. b (C-2) |
| 13. ab (C-1) | 38. a (C-2) | 63. a (C-2) |
| 14. b (C-1) | 39. a (C-2) | 64. a (C-2) |
| 15. a (C-1) | 40. b (C-2) | 65. a (C-2) |
| 16. b (C-1) | 41. a (C-2) | 66. b (C-2) |
| 17. c (C-1) | 42. b (C-2) | |
| 18. a (C-1) | 43. a (C-2) | |
| 19. b (C-2) | 44. a (C-2) | |
| 20. a (C-2) | 45. a (C-2) | |
| 21. a (C-2) | 46. b (C-2) | |
| 22. b (C-2) | 47. a (C-2) | |
| 23. a (C-2) | 48. a (C-2) | |
| 24. a (C-2) | 49. b (C-2) | |
| 25. a (C-2) | 50. a (C-2) | |

MODULE: CONSTRUCTION TECHNIQUES

UNIT II: SKETCHING

UNIT OBJECTIVE

After completion of this unit, the student should be able to state the purpose and procedures for various types of sketching. The student should also be able to sketch straight lines, arcs, circles, and ellipses. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring ____ percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

- 1.1 Match terms related to sketching techniques with their correct definitions.
- 1.2 State purposes of sketching.
- 1.3 Select true statements concerning rules in sketching.
- 1.4 Arrange in order the steps in completing a drawing.
- 1.5 List two types of sketch views.
- 1.6 Select true statements concerning guidelines for sketching straight lines.
- 1.7 Arrange in order the steps for sketching arcs.
- 1.8 Arrange in order the steps for sketching circles.
- 1.9 Match methods for sketching ellipses with their procedures.
- 1.10 Arrange in order the steps for blocking in a view.
- 1.11 Define two methods for proportioning a sketch.
- 1.12 List three ways to interpret the meaning of lines.
- 1.13 Demonstrate the ability to:
 - a. Sketch straight lines.
 - b. Sketch arcs.
 - c. Sketch circles.
 - d. Sketch an object using arcs and circles.
 - e. Sketch an ellipse.

MODULE: CONSTRUCTION TECHNIQUES

UNIT II: SKETCHING

CONTENTS OF THIS UNIT

- A. Objective sheet
- B. References
- C. Notes to the instructor
- D. Lesson plans
 - 1. Lesson 1: SKETCHING TECHNIQUES
 - a. Information outline
 - b. Transparency masters
 - TM 1.1: Straight Line Sketches
 - TM 1.2: Sketching Arcs, Circles and Ellipses
 - TM 1.3: Steps in Blocking in a View
 - TM 1.4: Proportion in Sketching
 - TM 1.5: Meaning of Lines
 - c. Assignment sheets
 - AS 1.1: Sketch Straight Lines
 - AS 1.2: Sketch Arcs
 - AS 1.3: Sketch Circles
 - AS 1.4: Sketch an Object Using Arcs and Circles
 - AS 1.5: Sketch an Ellipse
- E. Unit test
- F. Answers to unit test

REFERENCES

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3. Dygdon, John Thomas and Henry Cecil Spencer. Basic Technical Drawing. New York 10022: Macmillan Publishing Co., Inc., 1968.
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NOTES TO THE INSTRUCTOR

- A. Suggested approaches to teaching this unit
1. Discuss advantages and disadvantages of sketching.
 2. Demonstrate to the class the techniques used in making a field sketch.
 3. Practice sketching techniques.

MODULE: CONSTRUCTION TECHNIQUES

UNIT II: SKETCHING

LESSON 1: SKETCHING TECHNIQUES

I. Terms and definitions

- A. **A picture is worth a thousand words**--a concept used by drafters, architects, and engineers to express an idea on paper so that it can be understood by other people involved
- B. **Arc**--any portion of the circumference of a circle
- C. **Diameter**--the distance across a circle passing through its center point
- D. **Ellipse**--a foreshortened circle having a major axis and minor axis
- E. **Focus (foci)**--a point(s) at which lines come toward each other or move away from each other
- F. **Freehand technical sketching**--making a drawing without the use of instruments, yet with care taken to obtain the correct line widths

NOTE: The drawing must not be crude or sloppy.
- G. **Radius**--the distance from the center point of a circle to the outside circumference
- H. **Sketch lines**--freehand connections between two or more points
- I. **Major axis**--the long axis passing through the center of an ellipse
- J. **Minor axis**--the short axis of an ellipse passing through the center and perpendicular to the major axis

II. Purposes of sketching

- A. Preliminary approach to a problem before going to the expense of making an instrument drawing
- B. To give the drafter a better picture of the object to be drawn
- C. For recording notes and technical information in the shop or field for future use in the drafting department
- D. As an aid to "think through" the solution to an engineering-type problem

III. Rules in sketching

- A. A scale is not required
- B. Small objects are sketched larger than their normal size
- C. Freehand lines are rough, not rigid

- D. Sketches are drawn in proportion
 - E. Line contrast should be used
 - F. A soft pencil should be used
 - G. Finished linework should be dark and conform to alphabet of line standards
 - H. Sketches are dimensioned the same as machine drawings
- IV. Steps in completing a drawing
- A. Select necessary views
 - B. Block in lightly the shape of the object
 - C. Block in details in each view
 - D. Erase unwanted construction lines
 - E. Darken lines
- V. Types of sketch views
- A. Pictorial
 - B. Multiview
- VI. Guidelines for sketching straight lines (TM 1.1)
- A. Properly locate end points of line
 - B. By trial movement from left point to right point, position arm without marking on the paper
 - C. Keep your eye on the point where the line will end and sketch short, light lines between points
- NOTE:** Do not permit your eye to follow the pencil.
- D. Erase unneeded lines with a soft eraser and darken the remaining line to form one uniformly wide, continuous line
- NOTE:** At this stage, your eye needs to lead the pencil along the light sketch line.
- E. Draw straight lines that are parallel to the drafting table edge (border lines) by aligning the paper on the drafting board edge and letting the third and fourth fingers of the drawing hand act as a guide by sliding them along the edge of the board while drawing the line
- (CAUTION:** This should be done only on tables with proper edging material.)
- F. Rotate the paper for inclined straight lines to a position that would make them straight lines

- G. Estimate angles by sketching a right angle and a 45° angle; subdivide into 15° angles, and then obtain the required angle
- H. Erase all unneeded construction lines
- VII. Steps for sketching arcs (TM 1.2)
 - A. Sketch right angle at the proper length
 - B. Box in to form a square and mark proper diagonal
 - C. Mark off proper length on diagonal
 - D. Darken in arc
- VIII. Steps for sketching circles (TM 1.2)
 - A. Sketch in box to proper scale and mark midpoint of each line of square
 - B. Sketch in diagonals in square and mark off proper length on diagonals
 - C. Darken in circle
- IX. Methods and procedures for sketching ellipses (TM 1.2)
 - A. Method 1
 - 1. Sketch in a rectangle the length of the major axis and minor axis and mark midpoint of each line of rectangle
 - 2. Sketch a circular arc on each line of the rectangle
 - 3. Darken in ellipse
 - B. Method 2
 - 1. Sketch in major axis and minor axis
 - 2. Sketch a circular arc on each end of an axis line
 - 3. Darken in ellipse
- X. Steps for blocking in a view (TM 1.3)
 - A. Block in main shapes of object
 - B. Sketch in arcs and circles
 - C. Darken final lines
 - D. Erase construction lines
- XI. Methods for proportioning a sketch (TM 1.4)
 - A. Method 1--Use a piece of cardboard to mark off some unit of measurement (such as a $1/4"$ to form some scale); then, measure the actual object

NOTE: When sketching, it is important to keep the sketch in proportion.

- B. Method 2--First, determine the overall width and height of the object; then, sketch in the medium areas (by use of diagonals if necessary); finally, sketch in the small details

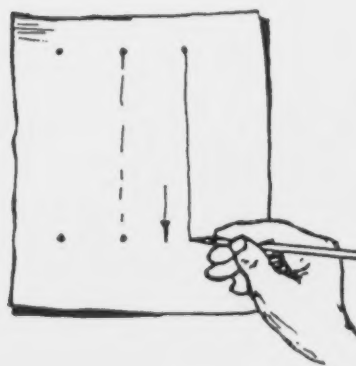
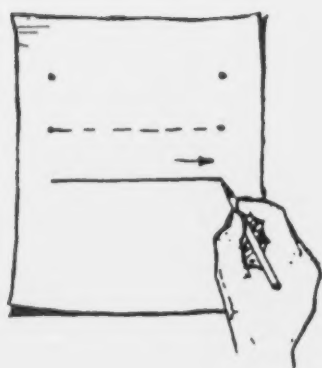
NOTE: When the item has numerous curves, it is best to use graph paper.

XII. Ways to interpret the meaning of lines (TM 1.5)

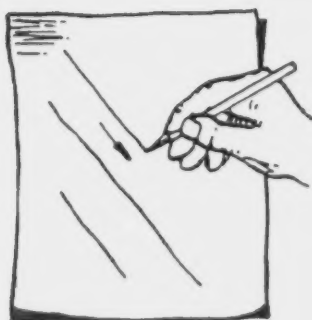
- A. A visible or hidden line can mean (indicate) the intersection of two surfaces
- B. A visible or hidden line can mean (indicate) an edge view of a surface
- C. A visible or hidden line can mean (indicate) a contour view of a curved surface

NOTE: It is necessary to examine all views carefully to determine their meaning since no shading is used on working drawings.

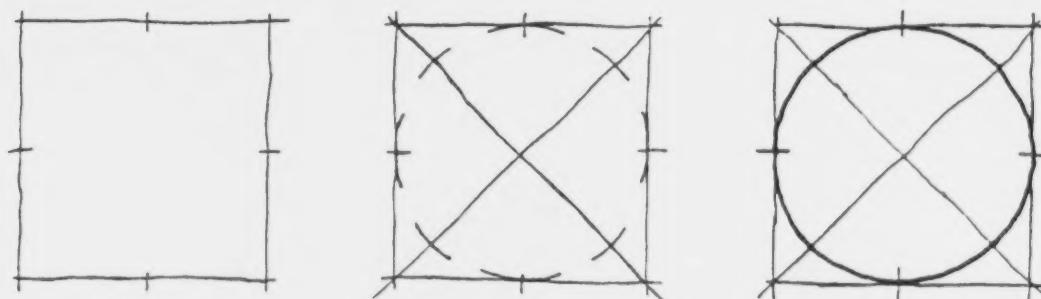
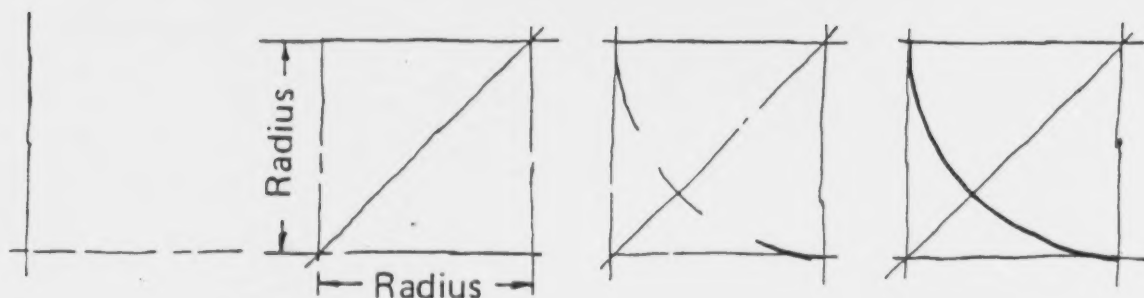
Straight Line Sketches



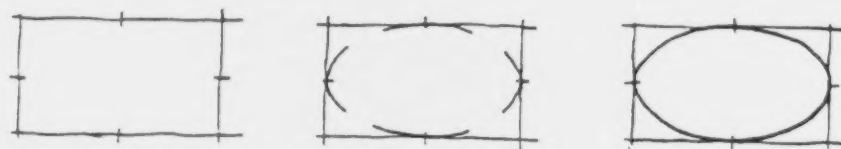
Keep eye on end point



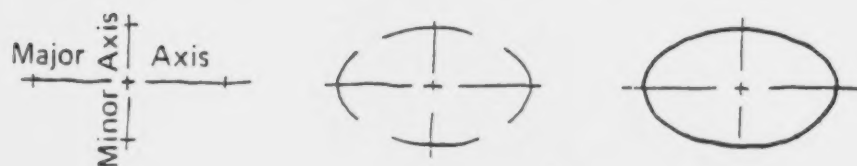
Sketching Arcs, Circles, and Ellipses



Method 1

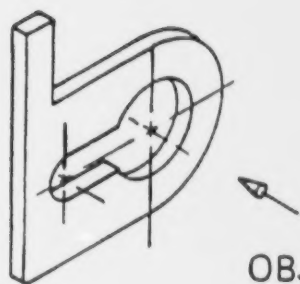


Method 2



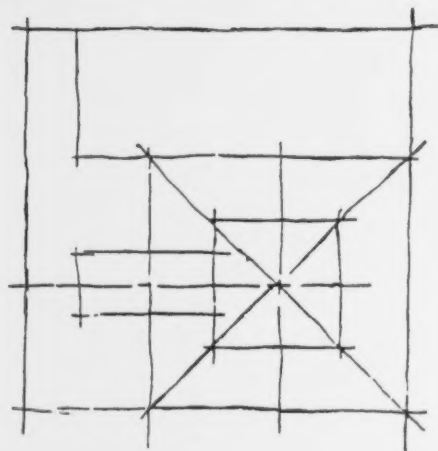
Sketching 37

Steps in Blocking in a View

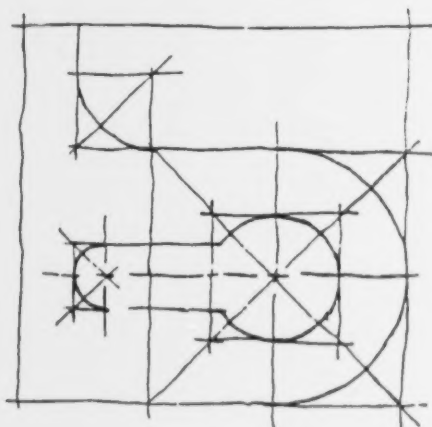


OBJECT

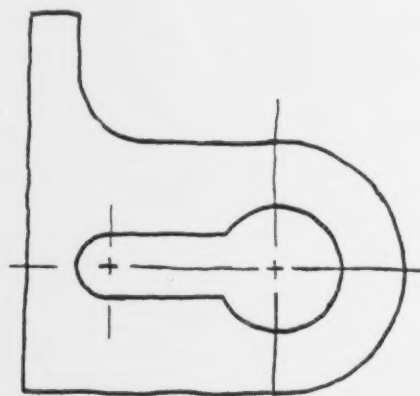
Block in Main Shapes



Sketch Arcs and Circles



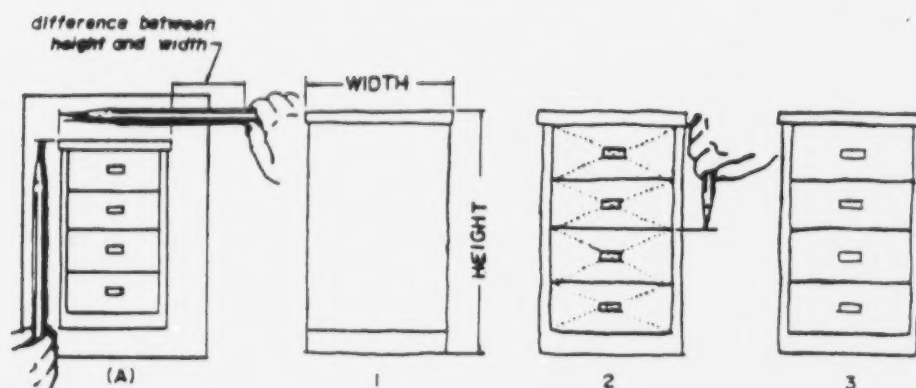
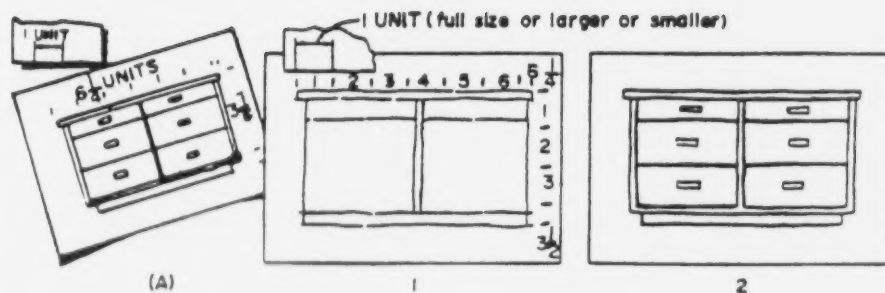
Darken Final Lines



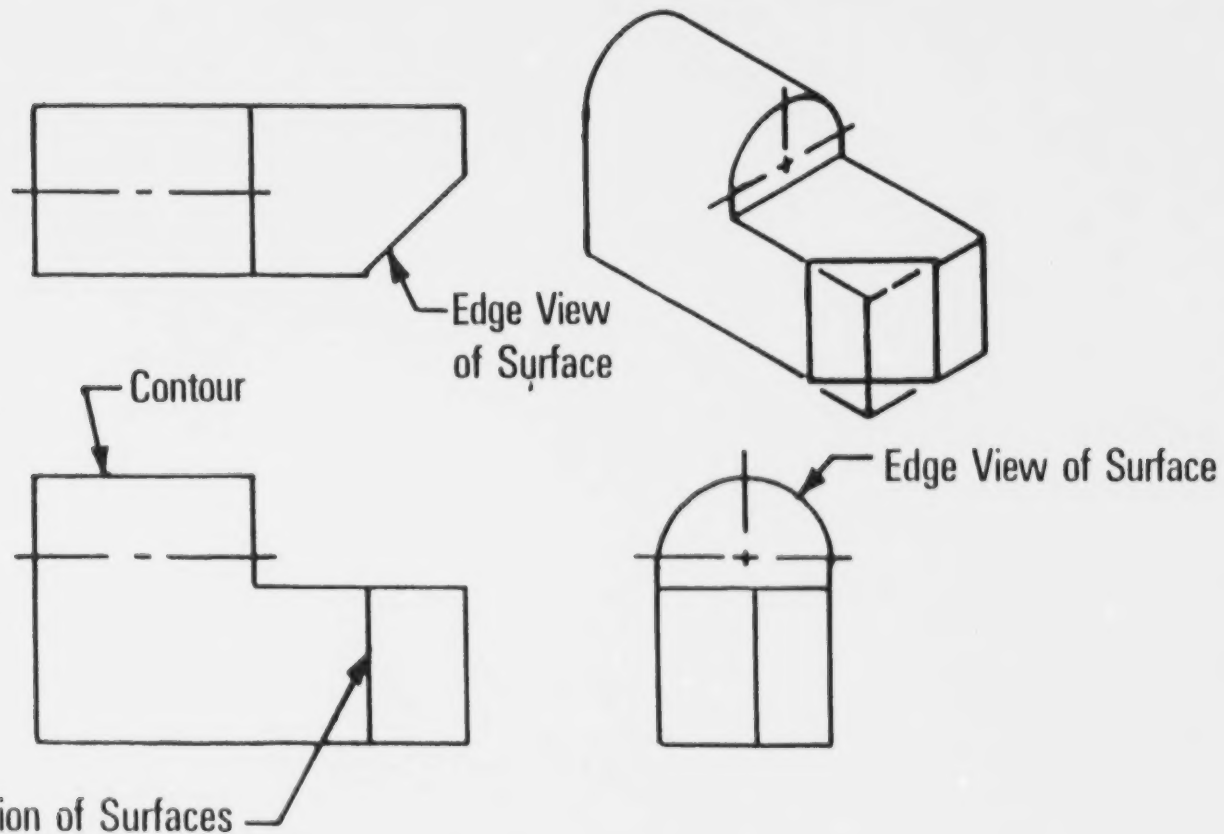
Sketching

39

Proportion in Sketching



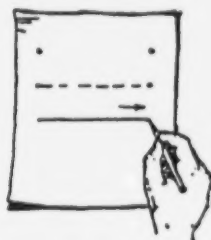
Meaning of Lines



SKETCH STRAIGHT LINES

Premise: Straight lines can be sketched by using the procedure in the following example.

Example:

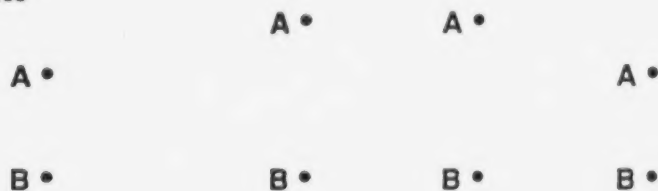


1. Draw two points
2. Draw dash lines connecting the two points
3. Darken and fill in dash lines

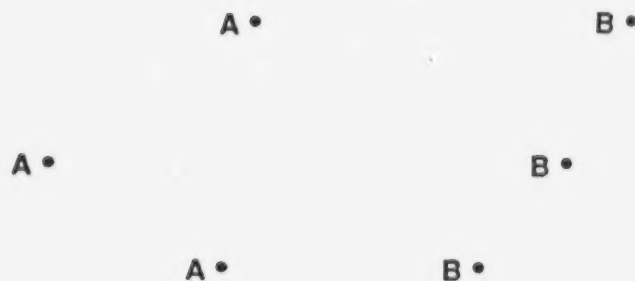
NOTE: The same procedure is used for vertical and inclined lines.

Directions: Sketch the following lines by connecting point A to point B.

Problem A: Vertical lines



Problem B: Horizontal lines



Problem C: Inclined lines

A •

B •

B •

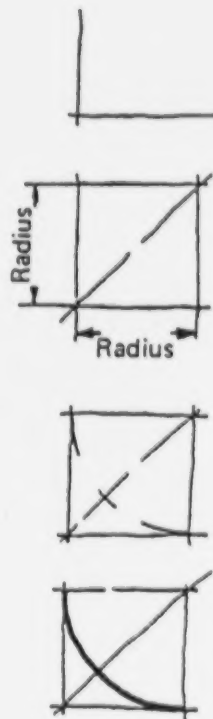
A •

SKETCH ARCS

Premise: Arcs can be sketched by using the procedure in the following example.

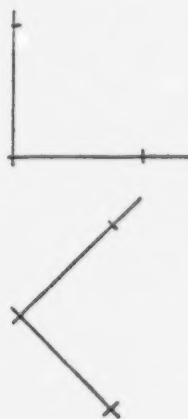
Example:

1. Sketch a box corner
2. Mark off radius distance from corner point
3. Swing a rough arc from center point
4. Darken arc



Directions: Sketch arcs in the following corners.

Problem:



Sketching 47

SKETCH CIRCLES

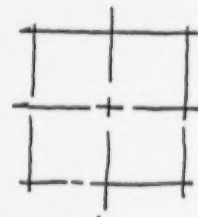
Premise: Circles can be sketched by using the procedure in the following example.

Example:

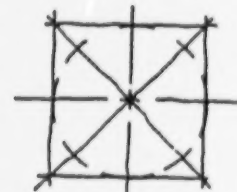
1. Sketch in center lines



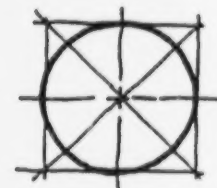
2. Box in circle at diameter required



3. Put in diagonal lines and mark radius points from center



4. Rotate wrist in a circular motion and connect circle points



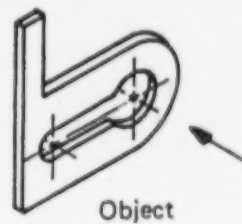
Directions: Sketch three circles below using $1/2"$ approximate radius.

SKETCH AN OBJECT USING ARCS AND CIRCLES

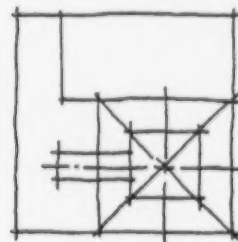
Premise: An object using arcs and circles can be sketched by using the procedure in the following example.

Example:

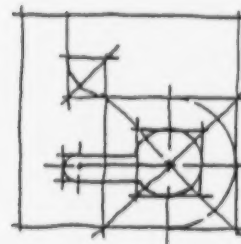
1. Decide which view of object is to be drawn



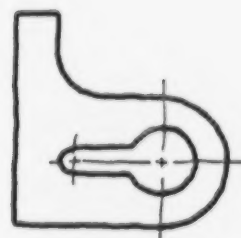
2. Box in overall shape of object



3. Sketch in arcs and circles

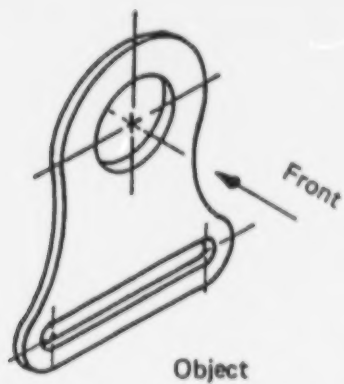


4. Erase construction lines and darken object



Directions: Sketch the front view of this object using steps shown on the previous page.

Problem:

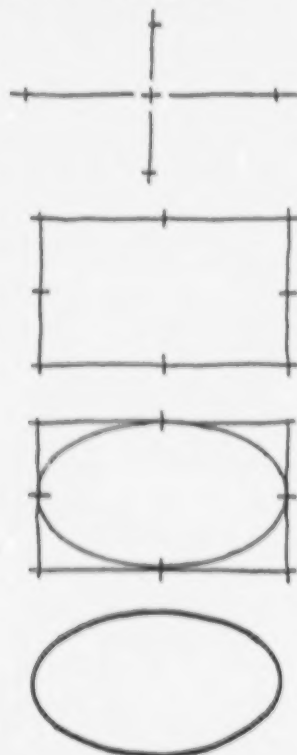


SKETCH AN ELLIPSE

Premise: An ellipse can be sketched by using the procedure in the following example.

Example:

1. Mark off major and minor axes on center lines
2. Box in outlines of the ellipse
3. Sketch in major and minor arcs of ellipse
4. Erase construction lines and darken ellipse outline



Directions: Sketch three ellipses using an approximate $3/4$ " major diameter and an approximate $1/2$ " minor diameter.

MODULE: CONSTRUCTION TECHNIQUES

UNIT II: SKETCHING

UNIT TEST

Match the terms on the right with their correct definitions on the left.

- | | |
|--|---|
| ___ 1. A concept used by drafters, architects, and engineers to express an idea on paper so that it can be understood by other people involved | a. Major axis |
| ___ 2. Making a drawing without the use of instruments, yet with care taken to obtain the correct line widths | b. Diameter |
| ___ 3. The distance from the center point of a circle to the outside circumference | c. Arc |
| ___ 4. The distance across a circle passing through its center point | d. Freehand technical sketching |
| ___ 5. Any portion of the circumference of a circle | e. Minor axis |
| ___ 6. A foreshortened circle having a major axis and a minor axis | ab. A picture is worth a thousand words |
| ___ 7. Freehand connections between two or more points | ac. Sketch lines |
| ___ 8. A point at which lines come toward each other or move away from each other | ad. Radius |
| ___ 9. The long axis passing through the center of an ellipse | ae. Ellipse |
| ___ 10. The short axis of an ellipse passing through the center | bc. Focus |

Mark an "a" for true statements concerning rules in sketching. Mark a "b" for false statements.

- ___ 11. An architect scale must be used in sketching
- ___ 12. Small objects are sketched larger than their normal size
- ___ 13. Freehand lines are finished and rigid
- ___ 14. Sketches do not need to be drawn in proportion
- ___ 15. Line contrast should be used
- ___ 16. A hard pencil should be used
- ___ 17. Finished linework should be dark and conform to line alphabet standards
- ___ 18. Sketches are never dimensioned

Mark an "a" for true statements concerning guidelines for sketching straight lines. Mark a "b" for false statements.

- ☐ 19. Properly locate end points of line
- ☐ 20. Position arm and mark heavily on the paper while moving from left point to right point
- ☐ 21. Keep your eye on the pencil and sketch short, heavy lines between points
- ☐ 22. Erase unneeded lines with a soft eraser and darken the remaining line to form one uniformly wide, continuous line
- ☐ 23. Draw straight lines that are parallel to the drafting table edge by aligning the paper on the drafting board edge and letting the third and fourth fingers of the drawing hand act as a guide by sliding them along the edge of the board while drawing the line
- ☐ 24. Do not rotate the paper to sketch inclined straight lines
- ☐ 25. Estimate angles by sketching a right angle and then a 45° angle; subdivide into 15° angles, and then obtain the required angle

Arrange in order the steps for sketching arcs by placing the correct sequence of letters in the appropriate blanks: a=1 b=2 c=3 d=4.

- ☐ 26. Mark off proper length on diagonal
- ☐ 27. Sketch right angle at the proper length
- ☐ 28. Darken in arc
- ☐ 29. Box in to form a square and mark proper diagonal

Arrange in order the steps for sketching circles by placing the correct sequence of letters in the appropriate blanks: a=1 b=2 c=3.

- ☐ 30. Sketch in diagonals in square and mark off proper length on diagonals
- ☐ 31. Darken in circle
- ☐ 32. Sketch in box to proper scale and mark midpoint of each line of square

Match methods for sketching ellipses on the right with their procedures on the left.

- ☐ 33. Sketch a circular arc on each end of an axis line a. Method 1
- ☐ 34. Sketch in a rectangle the length of the major axis and minor axis and mark midpoint of each line of rectangle b. Method 2

___ 35. Sketch a circular arc on each line of the rectangle

___ 36. Sketch in major axis and minor axis

Arrange in order the steps for blocking in a view by placing the correct sequence of letters in the appropriate blanks: a=1 b=2 c=3 d=4.

___ 37. Darken final lines

___ 38. Block in main shapes of object

___ 39. Erase construction lines

___ 40. Sketch in arcs and circles

41. Define two methods for proportioning a sketch.

a. Method 1: _____

b. Method 2: _____

42. List three ways to interpret the meaning of lines.

a. _____

b. _____

c. _____

43. State three purposes of sketching.

a. _____

b. _____

c. _____

44. List two types of sketch views.

a. _____

b. _____

ANSWERS TO UNIT II TEST (C3)

- | | | | |
|-----|----|-----|---|
| 1. | ab | 21. | b |
| 2. | d | 22. | a |
| 3. | ad | 23. | a |
| 4. | b | 24. | b |
| 5. | c | 25. | a |
| 6. | ae | 26. | c |
| 7. | ac | 27. | a |
| 8. | bc | 28. | d |
| 9. | a | 29. | b |
| 10. | e | 30. | b |
| 11. | b | 31. | c |
| 12. | a | 32. | a |
| 13. | b | 33. | b |
| 14. | b | 34. | a |
| 15. | a | 35. | a |
| 16. | b | 36. | b |
| 17. | a | 37. | c |
| 18. | b | 38. | a |
| 19. | a | 39. | d |
| 20. | b | 40. | b |
41. Method 1: use a piece of cardboard to mark off some unit of measurement; then, measure the actual object
- Method 2: First, determine the overall width and height of the object; then, sketch in the medium areas; finally, sketch in the small details
42. a. A visible or hidden line can mean the intersection of two surfaces
- b. A visible or hidden line can mean an edge view of a surface
- c. A visible or hidden line can mean a contour view of a curved surface

43. Any three of the following:
- a. Preliminary approach to a problem before going to the expense of making an instrument drawing
 - b. To give the drafter a better picture of the object to be drawn
 - c. For recording notes and technical information in the shop or field for future use in the drafting department
 - d. As an aid to "think through" the solution to an engineering-type problem
- 44.
- a. Pictorial
 - b. Multiview

MODULE: CONSTRUCTION TECHNIQUES

UNIT III: LETTERING

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the reasons for neat lettering, the procedure for forming letters, and the use of guidelines and the instruments for making them. The student should also be able to relate paper size to proper lettering height and draw both lower-case and upper-case vertical and inclined Gothic letters. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment sheets and by scoring ____ percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

- 1.1 Select true statements concerning reasons and rules for neat lettering.
- 1.2 List guidelines for letter selection.
- 1.3 Select true statements concerning the procedures for forming letters.
- 1.4 Select true statements concerning the rules for left-handed drafters.
- 1.5 Select the purposes of guidelines.
- 1.6 Select true statements concerning rules for making guidelines.
- 1.7 List reasons for using Gothic single-stroke vertical and inclined lettering.
- 1.8 Select basic rules for learning to letter.
- 1.9 Select true statement concerning rules for spacing.
- 1.10 Match the general classes of leads with their uses.
- 1.11 Distinguish between the disadvantages of hard and soft leads.
- 1.12 Distinguish between suggested leads used for lettering and for constructing guidelines.
- 1.13 List types of line guides used for laying out guidelines for lettering.
- 1.14 Arrange in order the suggested steps in using a Braddock Rowe triangle.
- 1.15 Arrange in order the suggested steps in using an Ames type lettering guide.
- 1.16 Match the name of lettering instruments with the correct description.
- 1.17 Select true statements concerning rules for different types of lettering.
- 1.18 Complete a chart showing recommended lettering height in relation to paper size.
- 1.19 Identify common problems in lettering uniformity.

- 1.20 Discuss common problems in lettering stability.
- 1.21 Demonstrate the ability to:
- a. Select and sharpen lead correctly.
 - b. Operate a Braddock Rowe triangle to construct guidelines.
 - c. Operate an Ames type lettering guide to construct guidelines.
 - d. Construct vertical Gothic lettering and numerals.
 - e. Construct inclined Gothic lettering and numerals.
 - f. Construct vertical lower-case Gothic lettering.
 - g. Construct inclined lower-case Gothic lettering.
 - h. Prepare vertical and inclined lettering exercises using freehand and mechanical lettering devices.

MODULE: CONSTRUCTION TECHNIQUES

UNIT III: LETTERING

CONTENTS OF THIS UNIT

- A. Objective sheet
- B. References
- C. Notes to the instructor
- D. Lesson plans
 - 1. Lesson 1: FREEHAND AND MECHANICAL LETTERING
 - a. Information outline
 - b. Transparency masters
 - TM 1.1: Rules for Making Guidelines
 - TM 1.2: Steps in Using a Braddock Rowe Triangle
 - TM 1.3: Steps in Using an Ames Type Lettering Guide
 - TM 1.4: Types of Lettering Instruments
 - TM 1.5: Types of Lettering Instruments (Continued)
 - TM 1.6: Types of Lettering Instruments (Continued)
 - TM 1.7: Vertical Gothic Lettering
 - TM 1.8: Inclined Gothic Lettering
 - TM 1.9: Vertical Gothic Lower-Case Lettering
 - TM 1.10: Inclined Gothic Lower-Case Lettering
 - TM 1.11: Inclined Lettering Uniformity
 - TM 1.12: Vertical Lettering Uniformity
 - c. Assignment Sheets
 - AS 1.1: Select and Sharpen Lead Correctly
 - AS 1.2: Operate a Braddock Rowe Triangle to Construct Guidelines
 - AS 1.3: Operate an Ames Type Lettering Guide to Construct Guidelines
 - AS 1.4: Construct Vertical Gothic Lettering and Numerals
 - AS 1.5: Construct Inclined Gothic Lettering and Numerals
 - AS 1.6: Construct Vertical Lower-Case Gothic Lettering
 - AS 1.7: Construct Inclined Lower-Case Gothic Lettering
 - AS 1.8: Prepare Vertical and Inclined Lettering Exercises Using Freehand and Mechanical Lettering Devices
- E. Unit test
- F. Answers to unit test

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NOTES TO THE INSTRUCTOR

- A. Suggested approaches to teaching this unit
1. Use file drawings to demonstrate to the class examples of correct and incorrect lettering.
 2. Show lettering templates that may be used in drafting.
 3. Demonstrate the use of different types of lettering instruments and guides.

MODULE: CONSTRUCTION TECHNIQUES

UNIT III: LETTERING

LESSON 1: FREEHAND AND MECHANICAL LETTERING

- I. Reasons and rules for neat lettering
 - A. Since approximately 20% of a drafter's time is used in lettering, neat lettering conserves time and money for the individual and the company
 - B. Lettering can greatly affect the overall appearance of a drawing
 - C. Most drawings are reproduced, therefore, the lettering must be done with neatness, accuracy, speed, legibility, and be a dense black
 - D. The letters must be formed very carefully and not crowded together or they will run together when reproduced
 - E. When additions or revisions are made to a drawing, the original style of lettering should be matched
- II. Guidelines for letter selection
 - A. For machine drawings, upper-case (capital) letters are used and may be vertical or inclined

NOTE: Vertical and inclined letters should never be mixed on the same drawing.
 - B. For topographic drawings or maps, lower-case letters are used for notes

NOTE: Vertical letters are a little more legible than slant letters; however, they are more difficult to draw.
- III. Procedure for forming letters
 - A. The vertical or inclined strokes of letters are usually formed by finger movement
 - B. The horizontal strokes of letters are made by a movement of the hand at the wrist along with a very slight finger movement
 - C. Ovals of the letters are formed by a movement of the hand and fingers together
 - D. The forearm should be at a 90° angle to the area to be lettered and rest on the drawing board for all lettering movements
- IV. Rules for left-handed drafters
 - A. The left-handed drafter should follow a system of strokes that will involve pulling the pen or pencil instead of pushing it

NOTE: Pushing the pen or pencil tends to dig into the paper.
 - B. Vertical and inclined strokes should be done from top to bottom

- C. Movement on horizontal strokes should be done from right to left

NOTE: When lettering, a left-hander should normally take a position exactly opposite that of a right-hander; the left-handers that letter with a hooked wrist have more difficulty and must adopt a system that seems best for their own particular habits.

V. Purposes of guidelines

- A. To keep letters exactly the same height
- B. To keep letters spaced properly
- C. To keep letters positioned in the same direction
- D. To improve the overall composition of lettered information

VI. Rules for making guidelines (TM 1.1)

- A. Paper should be aligned and corners secured with tape to working surface
- B. Horizontal guidelines should be made with the aid of a lettering guide
- C. Guidelines should not reproduce
- D. Horizontal guidelines should be accurately spaced
- E. Lead used to make guidelines should be very sharp and of a good quality
- F. Guidelines should be used for all lettering

VII. Reasons for using Gothic single-stroke vertical and inclined lettering

- A. Saves time in production
- B. Easy to read and provides drawing consistency
- C. Students learn to use it quickly
- D. Cost of drawings is reduced

VIII. Basic rules for learning to letter

NOTE: When lettering, select a comfortable position either sitting or standing.

- A. Learn the shapes
- B. Learn the strokes
- C. Learn the rules of spacing
- D. Learn the practice with a determination to improve

IX. Rules for spacing

- A. Spacing between letters is determined by the area between two letters (0.06" or 1.5 mm), not just the distance between two letters
- B. The spacing of words is attained by using an imaginary letter "O" as a spacer
- C. The spacing between two sentences is attained by using an imaginary double letter "OO" as a spacer
- D. The space between two numerals separated by a decimal point (4.1) should be a minimum of 2/3 the height of the numerals
- E. The space between lines of lettering should be a minimum of 1/2 the height of the lettering and a maximum of the same height as the lettering
- F. Notes must be placed horizontally on the drawing

NOTE: To identify separate notes, at least double the height of the character is used.

- G. Use underline lettering only when special emphasis is needed

NOTE: The underline should be a minimum of 0.06" (1.5 mm) below the lettering.

- H. The division line in a common fraction should be parallel to the direction the dimension reads and the numerator and denominator of a fraction should be separated by a 0.06" (1.5 mm) space

RIGHT

$$\frac{5}{8}$$

$$\frac{1}{4}$$

$$\frac{1}{2}$$

$$\frac{18}{64}$$

WRONG

$$\frac{5}{8}$$

$$\frac{1}{4}$$

$$\frac{1}{2}$$

$$\frac{18}{64} - \frac{18}{64}$$

- I. A diagonal line is permissible only when fractions are placed in lists, tables, or notes
- J. Each numeral in a fraction should be the same height as a whole number

X. Uses of leads by their general class

A. Hard leads

1. Wherever extreme accuracy is required
2. Guidelines for lettering
3. Construction lines

B. Medium leads

1. General purpose work
2. The softer of these are used for:
 - a. Lettering
 - b. Technical sketching
 - c. Arrowheads
 - d. Any freehand work on drawings
3. The harder of these are used for:
 - a. Line work on drawings
 - b. The 2H and H leads are the two leads most often used on pencil drawings, which will be reproduced

C. Soft leads

1. Fine art drawing
2. Architectural rendering
3. Production illustration
4. Lettering

XI. Disadvantages of hard and soft leads

A. Disadvantages of hard leads--Use is restricted, apt to be too light

NOTE: Humidity is sometimes a problem. On humid days the paper absorbs moisture from the atmosphere and becomes soft; it will expand and become wrinkled. When this occurs a softer lead will be needed to offset the softening of the paper. For example, if the drafter has been using a 4H lead, use a 2H until the weather clears up.

B. Disadvantages of soft leads

1. Will result in smudged, rough lines
2. Difficult to erase

3. Must be continually sharpened

XII. Suggested leads

A. Lettering

1. HB
2. F
3. H
4. 2H

B. Constructing guidelines

1. 4H
2. 5H
3. 6H
4. Non-reproducible blue

NOTE: Guidelines should be light enough so that when a drawing is held at arms length they cannot be seen.

XIII. Types of line guides used in laying out guidelines for lettering

- A. Braddock Rowe triangle
- B. Ames type lettering guide

XIV. Steps in using a Braddock Rowe triangle (TM 1.2)

- A. Align and secure paper to drawing surface with drafting tape on each corner
- B. Place Braddock Rowe triangle against top edge of drafting machine or parallel bar
- C. Select letter height, which is expressed in 1/32 (3/32 through 8/32)
- D. Sharpen lead
- E. Place pencil in appropriate holes for height of letter required and move triangle across horizontal blade
- F. When lettering upper-case letters, omit the middle guidelines, which are used for lower-case letters
- G. Construct guidelines vertically by using vertical blade or a triangle
- H. Incline guidelines by using a 68° notch on the Braddock Rowe triangle

XV. Steps in using an Ames types lettering guide (TM 1.3)

- A. Align and secure paper to drawing surface with drafting tape on each corner

- B. Place Ames type lettering guide against top edge of drafting machine or parallel bar
- C. Select appropriate letter height which is expressed in 1/32 and can be selected by rotation of the circular selector
- D. Sharpen lead
- E. Place lead in appropriate holes for height of letter required and move Ames type lettering guide across top edge of blade in a smooth, light motion
- F. When lettering uppercase letters, omit the middle guideline which is used for lowercase letters
- G. Construct guidelines vertically by using vertical blade or triangle
- H. Incline guideline by using the 68° slope on the Ames type lettering guide

XVI. Description of lettering instruments

- A. Leroy lettering instrument--an instrument consisting of a template, a scribe, and an inking pen (TM 1.4)

NOTE: A guide pin follows grooved letters in a template, and the ink point moves on the paper. Various sizes and styles of guides are available.
- B. Varigraph--a device for making a wide variety of either single stroke or "built-up" letters (TM 1.5)

NOTE: Angle of letters, size, and height of letters can be changed by adjustments on the body of the scribe.
- C. Letterguide--an instrument much like the varigraph (but simpler) which also makes a large variety of styles and sizes of letters (TM 1.5)

NOTE: It also operates with a guide pin moving in the grooved letters of the template while the pen, which is mounted on the adjustable arm, makes the letters in outline.
- D. Varityper--an instrument which uses a one-time carbon ribbon and has a near-standard typewriter keyboard with an open-ended carriage (TM 1.5)

NOTE: This allows it to receive various size drawings. Hundreds of instantly changeable typefaces are available for the varityper.
- E. Template--a thin, flat sheet of plastic with letters cut through the sheet (TM 1.5)

NOTE: A pencil is inserted into the groove and moved back and forth to form the shape of the letter. Spacing of individual letters must be done visually.
- F. Lettering machine--a machine that produces "type on tape" (TM 1.6)

NOTE: Bold black letters come out of a transparent tape that can be attached directly to the surface of a drawing. Type discs for the machine are easily interchangeable and come in four popular type styles in type sizes ranging from 8 to 36 point.

XVII. Rules concerning different types of lettering

A. Vertical Gothic (TM 1.7)

1. The number 1 and letter I have no width
2. The width of the letter W is $1 \frac{1}{3}$ times its height
3. Letters that are equal in height and width are A, M, O, Q, T, V, X, Y
4. All other letters not noted above have a width $\frac{5}{6}$ their height
5. All numerals except the numeral one have a width $\frac{5}{6}$ their height
6. If the center area of the following letters is placed at midheight of the line, it appears to be below center; therefore, these strokes are placed slightly above the center point of these letters: B, E, F, and H
7. When the heights vary on upper case letters, the small upper case letters are to be $\frac{2}{3}$ to $\frac{4}{5}$ the height of the large upper case lettering

Example:

LETTERING

8. Lettering is not writing but freehand drawing, and the six fundamental strokes of freehand drawing are used in lettering

Examples:

Vertical



Inclined



B. Inclined Gothic (TM 1.8)

1. The same rules for letter sizes and spacing that apply in vertical lettering apply in inclined lettering
2. Circular parts of letters should be made elliptical by having the major axis inclined at a 45° angle to the horizontal so they will appear to slant properly to the right

3. The letters A, V, W, X, and Y have sloping sides and are difficult to make unless an imaginary inclined center line is used and the letter is drawn symmetrically around it

NOTE: This method is a good one for beginning drafters to practice.

C. Vertical Gothic lower-case (TM 1.9)

1. The shapes of vertical lower-case lettering are based on the circle, circular arc, and straight line

NOTE: There are some variations.

2. The third stroke of the e is slightly above midheight of the letter
3. The horizontal strokes of the f and t are placed on the waist line, and are an equal distance from stroke number 1
4. On the letters h, m, n, and r, the curved strokes intersect the first stroke at roughly $\frac{2}{3}$ the distance from the base line to the waist line
5. On the letters g, j, and y, the descenders form a curve tangent to the drop line
6. The letters p and q terminate without curves on the drop line
7. When upper case and lower case letters are used, the lower case letter should be $\frac{2}{3}$ the height of the uppercase letter

NOTE: An exception to this rule is lettering for microfilm.

8. On lower-case letters, the ascending or descending stems are equal in length to the height of the capitals

D. Inclined Gothic lower-case (TM 1.10)

1. The same rules for letter sizes and spacing that apply in vertical lettering apply in inclined lettering
2. Circular parts of letters should be made elliptical by having the major axis inclined at a 45° angle to the horizontal so they will appear to slant properly to the right
3. The letters c, o, s, v, w, x, and z have the same form as their corresponding capitals

XVIII. Paper size and lettering standards

A. Paper size and letter height

Standard U.S. Paper Size	Metric Paper Size	Recommended Lettering Height		
		Millimeters	Decimals (inches)	Fractions (inches)
A	A4	3.2	0.125	1/8
B	A3	3.2	0.125	1/8
C	A2	4.0	0.156	5/32
D	A1	4.8	0.188	3/16
E	A0	4.8	0.188	3/16

NOTE: The larger the drawing the larger the lettering required.

XIX. Common problems in lettering uniformity (TM 1.11 and 1.12)

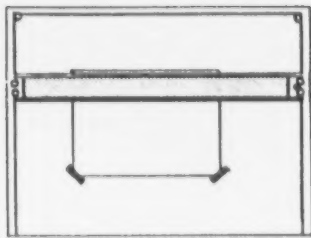
- A. Letters are not uniform in height
- B. Letters are not inclined or vertically uniform
- C. Letters are not uniform in stroke thickness
- D. Areas are not uniform between letters
- E. Style of letters is not uniform
- F. Areas are not uniform between words
- G. Inconsistent use of guidelines
- H. Following proper form, (i.e., letters "i" and "j" should not have bars)

XX. Common problems in lettering stability (TM 1.11 and 1.12)

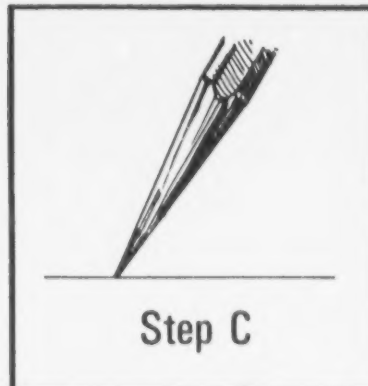
- A. On some letters, if the top portion is the same width as the bottom, the letters appear to be top heavy
- B. If the center area of certain letters is placed at midheight to the line, it appears to be below center; therefore, these strokes are placed slightly above the center point of the letters B, E, F, and H

Rules for Making Guidelines

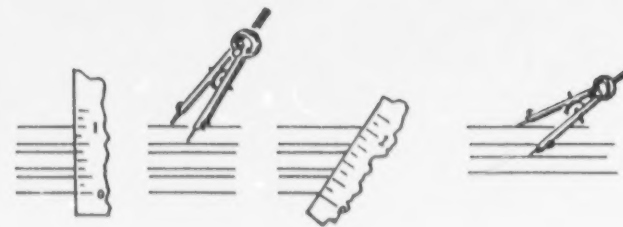
Step A



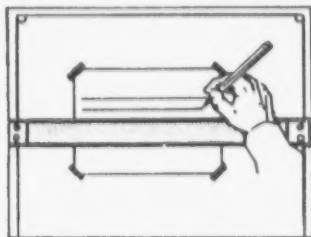
Step B



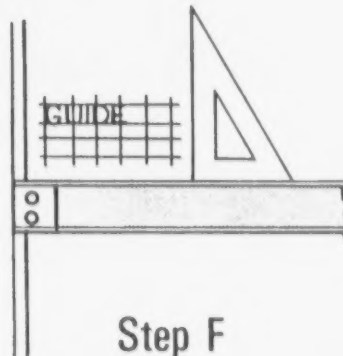
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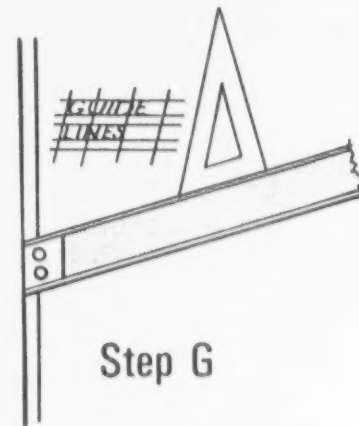
Step D



Step E

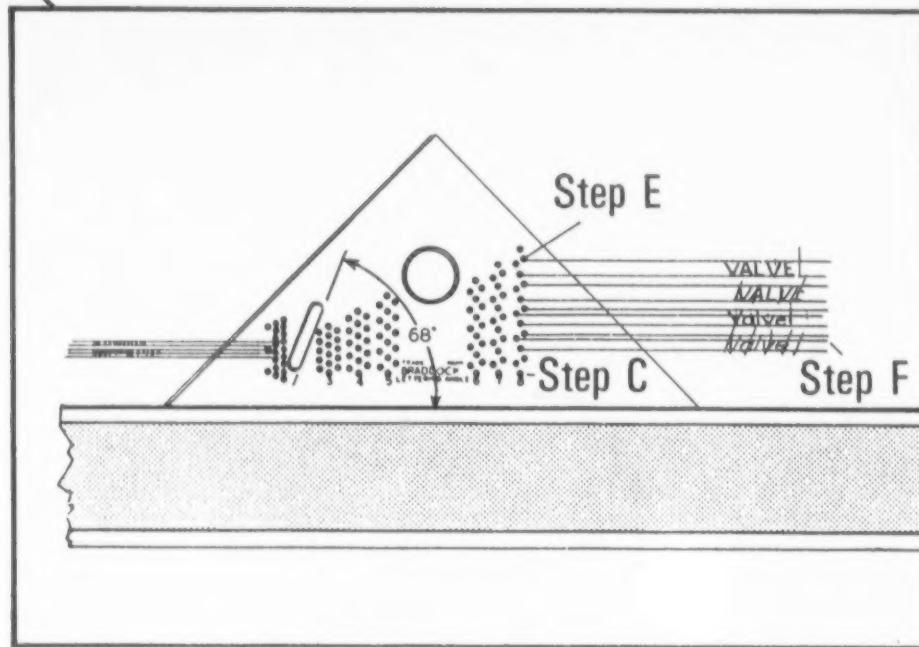
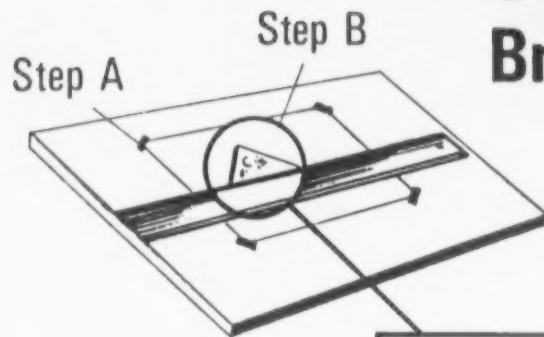


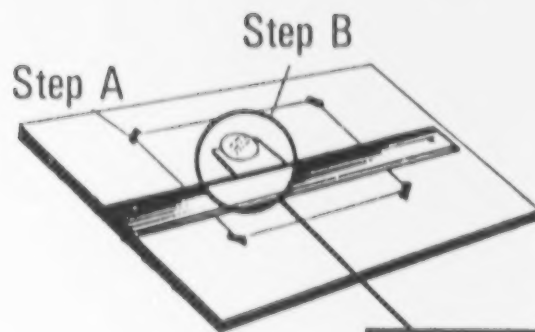
Step F



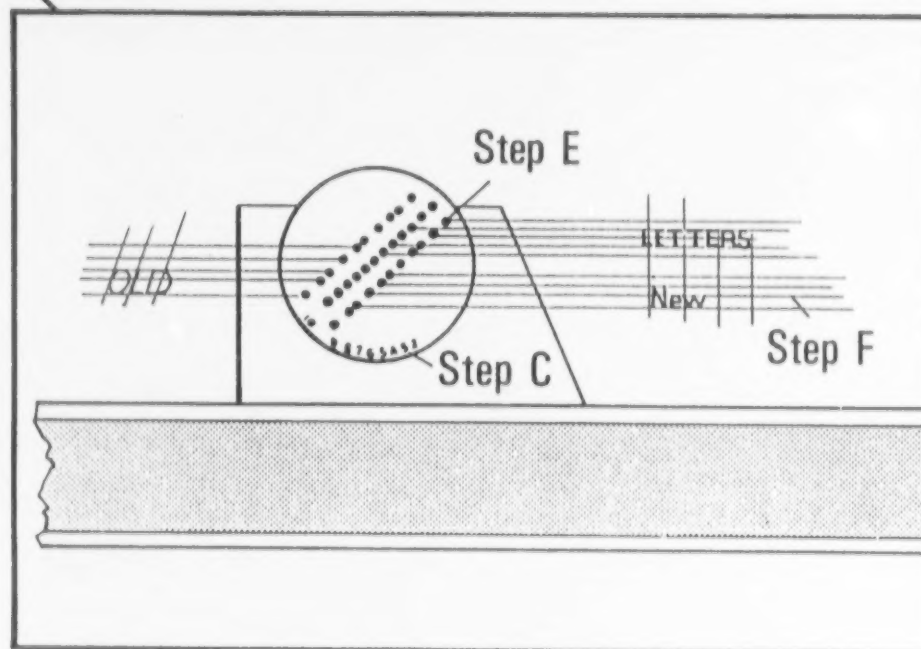
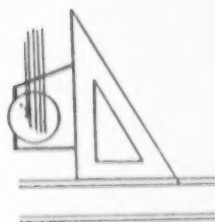
Step G

Steps in Using a Braddock Rowe Triangle

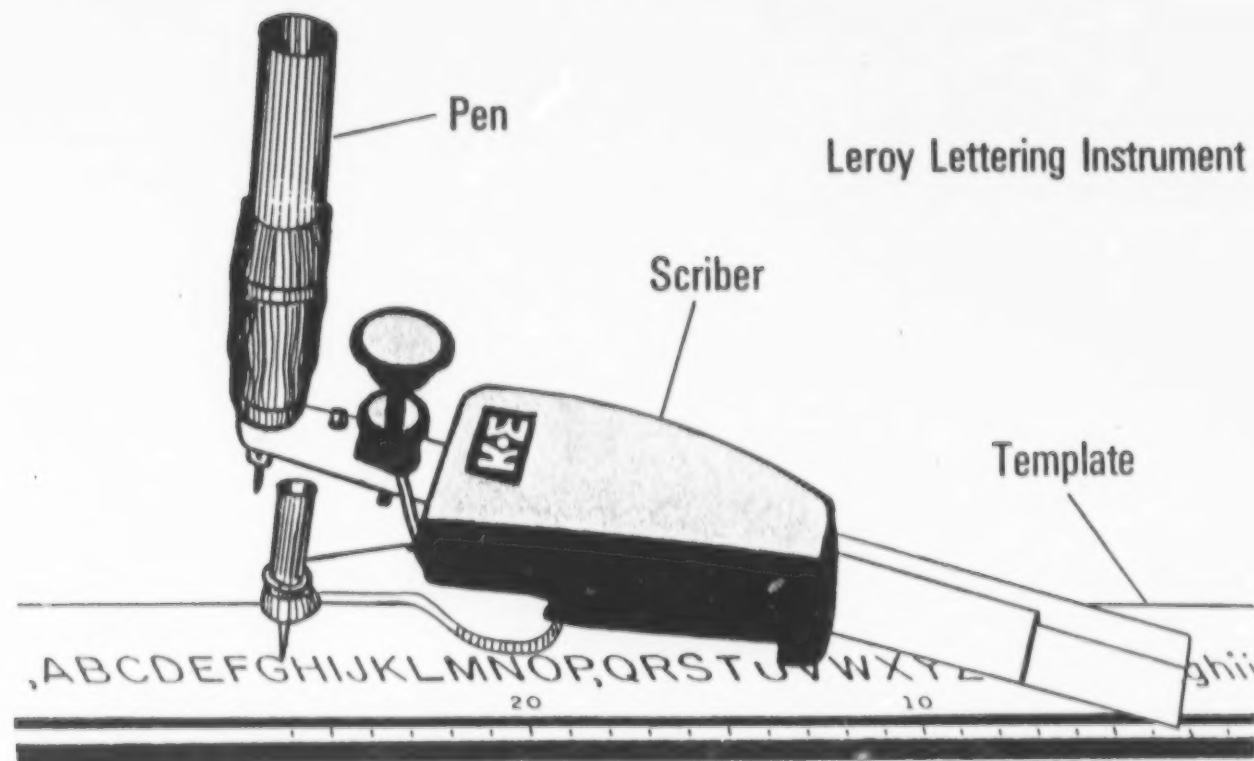




Steps in Using an Ames Type Lettering Guide



Types of Lettering Instruments

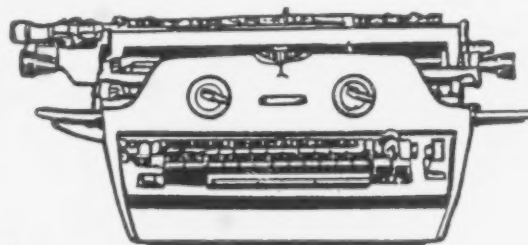


Types of Lettering Instruments



b. Varigraph, Italic Model Headwriter

VariTyper Corporation

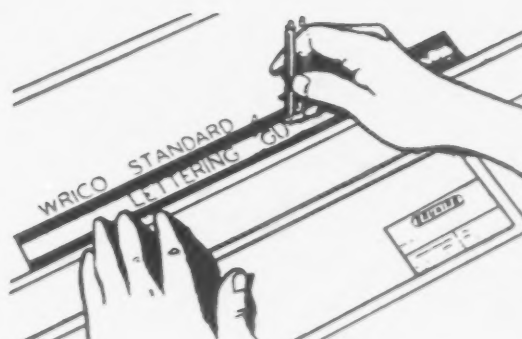


d. Vari Typer Office Composing Machine, Model 660

Courtesy Letterguide

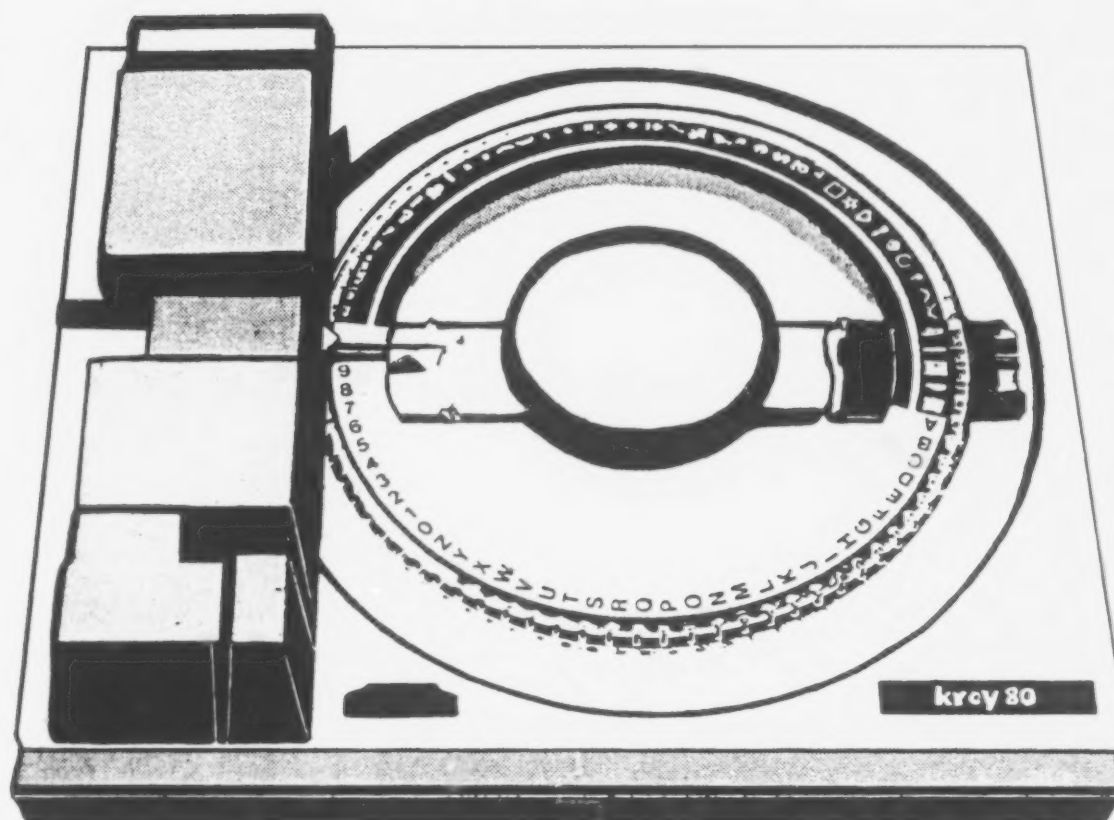


c. Letterguide



e. Template

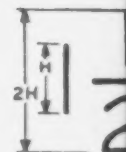
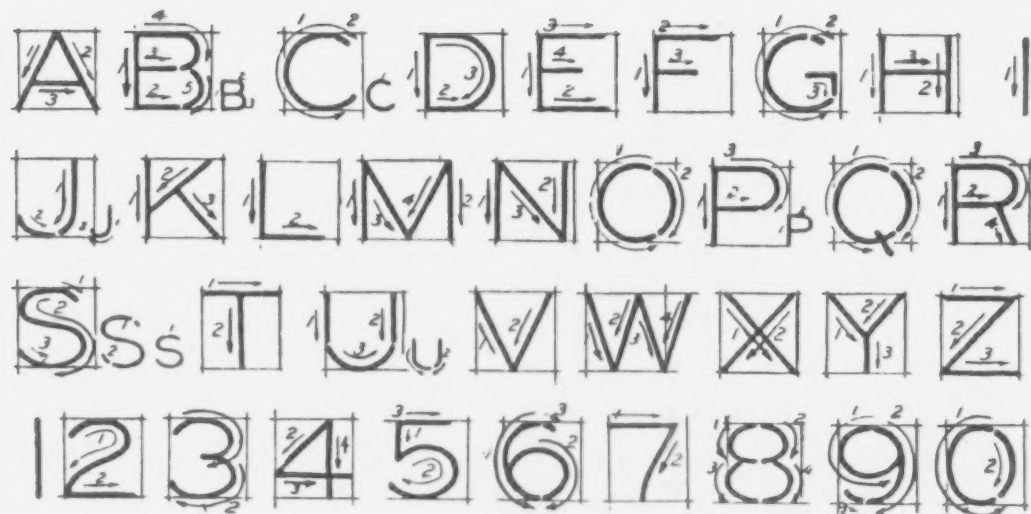
Types of Lettering Instruments



Lettering Machine

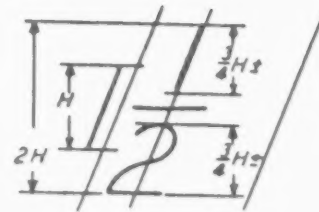
(Note--Available in either Manual or Electric)

Vertical Gothic Lettering



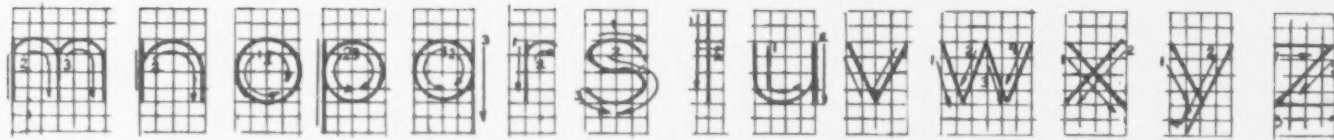
Inclined Gothic Lettering

A B C D E F G H I
J K L M N O P Q R
S T U V W X Y Z &



1 2 3 4 5 6 7 8 9 0

Vertical Gothic Lower Case Lettering



Inclined Gothic Lower Case Lettering

a b c d e f g h i j k l m n o

p q r s t u v w x y z

Inclined Lettering Uniformity

UNiFORM

A LETTERS NOT UNIFORM
IN HEIGHT

UNIFORM

B LETTERS ARE NOT UNIFORMLY
INCLINED

UNIFORM

C LETTERS NOT UNIFORM IN
STROKE THICKNESS

UN IFO R M

D AREAS ARE NOT UNIFORM
BETWEEN LETTERS

UniFoRM

E STYLE OF LETTERS IS
NOT UNIFORM

GOOD LETTERINGSHOULD
BE UNIFORM

F AREAS ARE NOT UNIFORM
BETWEEN WORDS

UNIFORM

G UNIFORM LETTERING

Lettering Stability

TOP-HEAVY
LETTERS

d d B E K S K Z H B H B

CORRECT
LETTERS

d d B E K S K Z H B S B

Vertical Lettering Uniformity

UNIFORM

A LETTERS NOT UNIFORM
IN HEIGHT

UNIFORM

B LETTERS ARE NOT VERTICALLY
UNIFORM

UNIFORM

C LETTERS NOT UNIFORM IN
STROKE THICKNESS

UNIFORM

D AREAS ARE NOT UNIFORM
BETWEEN LETTERS

Uniform

E STYLE OF LETTERS IS
NOT UNIFORM

GOOD LETTERINGSHOULD
BE UNIFORM

F AREAS ARE NOT UNIFORM
BETWEEN WORDS

UNIFORM

G UNIFORM LETTERING

Lettering Stability

TOP-HEAVY
LETTERS

c d b e k s x z 2 3 5 8

CORRECT
LETTERS

c d b e k s x z 2 3 5 8

SELECT AND SHARPEN LEAD CORRECTLY

- I. Tools and equipment
 - A. Lead holder or pencil
 - B. Lead pointer
 - C. Drawing paper or media
 - D. Pencil pointer
 - E. Paper towel or cleaning cloth
 - F. Styrofoam point cleaner or tissue
- II. Procedure
 - A. Select correct lead weight
 - B. Sharpen lead to correct point
 - C. After lead has been sharpened correctly, remove excess graphite from pencil using styrofoam point cleaner or tissue

NOTE: This will prevent lead from smudging drawing.

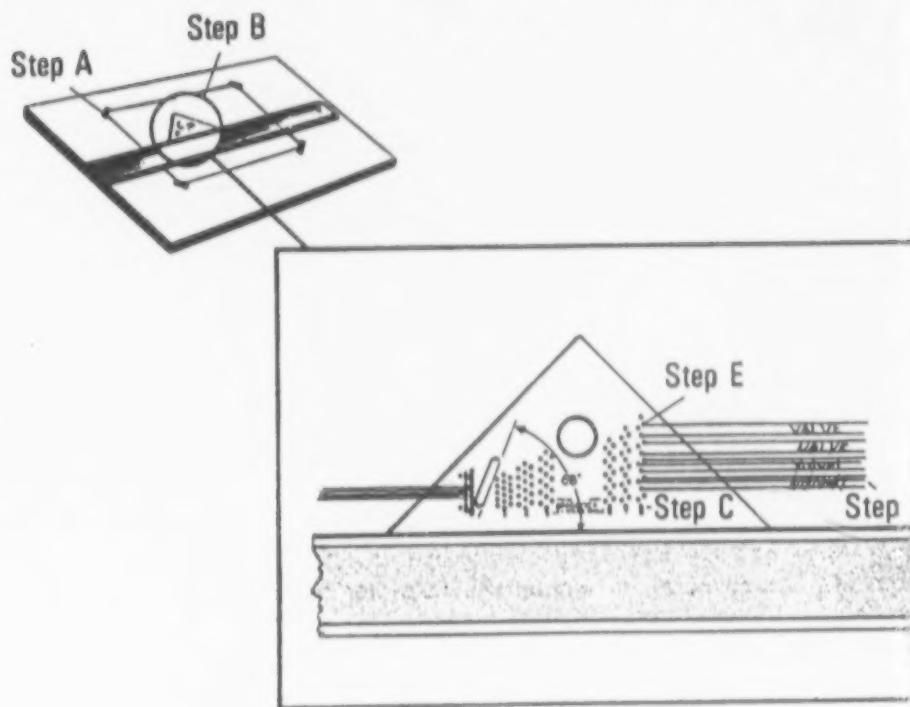
Pencil**Lead Holder**

OPERATE A BRADDOCK ROWE TRIANGLE TO CONSTRUCT GUIDELINES

- I. Tools and equipment
 - A. Braddock Rowe triangle
 - B. Drafting machine or parallel bar
 - C. Lead holder
 - D. Drawing media
 - E. Drawing surface
- II. Procedure (TM 1.2)
 - A. Align and secure paper to drawing surface with drafting tape on each corner
 - B. Place Braddock Rowe triangle against top edge of machine or bar
 - C. Select letter height which is expressed in 1/32 (3/32 through 8/32 are indicated on the triangle)
 - D. Sharpen lead
 - E. Place pencil in appropriate holes for height of letter required and move triangle across horizontal blade
 - F. Omit the middle guideline which is used for lowercase letters when lettering uppercase letters

NOTE: Guidelines may be constructed vertically by using vertical blade or triangle.

III. Diagram of the procedure



OPERATE AN AMES TYPE LETTERING GUIDE TO CONSTRUCT GUIDELINES**I. Tools and equipment**

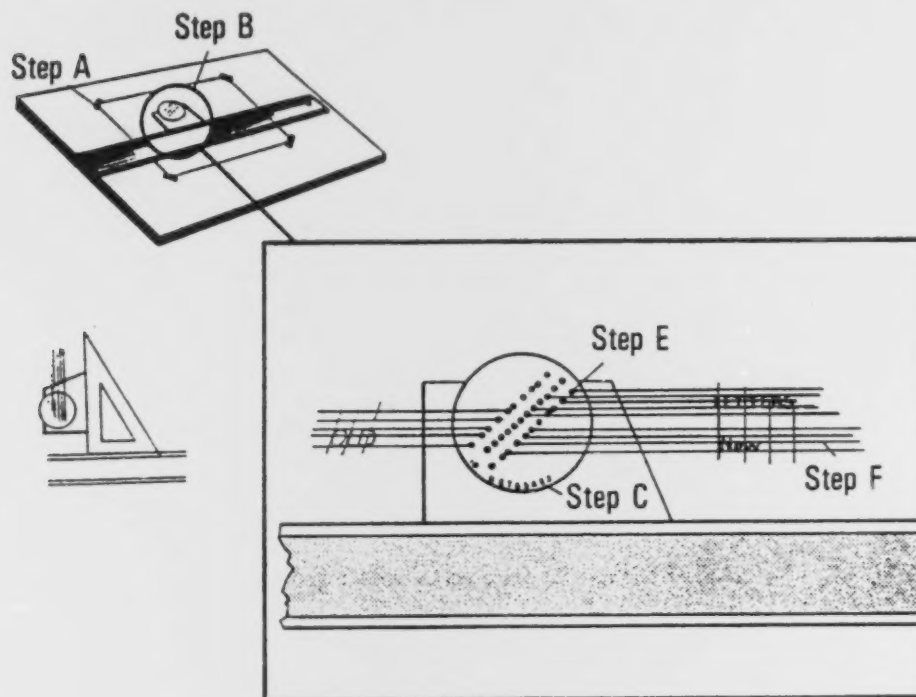
- A. Ames type lettering guide
- B. Drafting machine or parallel bar
- C. Lead holder
- D. Drawing media
- E. Drawing surface

II. Procedure (TM 1.3)

- A. Align and secure paper drawing surface with drafting tape on each corner
- B. Place Ames type lettering guide against top edge of machine or bar
- C. Select appropriate letter height which is expressed in 1/32
NOTE: It can be selected by rotation of the circular selector.
- D. Sharpen lead
- E. Place lead in appropriate holes for height of letter required and move Ames type lettering guide across top edge of blade in a smooth, light motion
- F. Omit the middle guideline which is used for lowercase letters when lettering uppercase letters

NOTE: Guidelines may be constructed vertically by using vertical blade or triangle.

III. Diagram of the procedure



CONSTRUCT VERTICAL GOTHIC LETTERING AND NUMERALS

I. Tools and equipment

- A. Lead holder or pencil
- B. Drafting tape
- C. Drawing surface
- D. Scale or lettering guide
- E. Drafting machine or parallel bar
- F. Pencil pointer

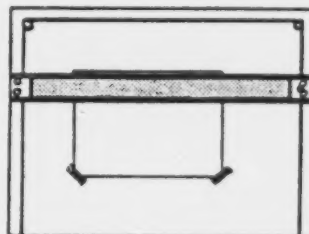
II. Procedure (TM 1.7)

- A. Secure lettering exercise paper to surface with tape
- B. Prepare point of lead for lettering
- C. Hold lead holder in correct position
- D. Study forms and strokes of letters and numerals shown in diagram
- E. Copy letters and numerals on guidelines

NOTE: Use proper form and stroke techniques.

III. Diagram of the procedure

- A. Obtain A size drawing media



- B. Prepare point of lead

NOTE: Point should be dulled slightly to give desired width of letter elements.



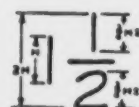
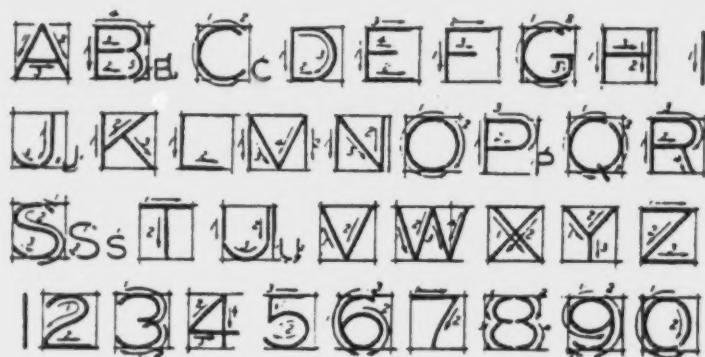
C. Use correct lead position

NOTE: Use an even pressure and rotate the lead in fingers after every few strokes to get uniform lines.



D. Study form of letters

NOTE: Trace over letters to learn strokes of each letter and numeral.



E. Construct guidelines

NOTE: Space $1/4"$ apart and copy letters and numerals shown in step D. Use space below for lettering exercise.

CONSTRUCT INCLINED GOTHIC LETTERING AND NUMERALS

I. Tools and equipment

- A. Lead holder or pencil
- B. Drafting tape
- C. Drawing surface
- D. Scale or lettering guide
- E. Drafting machine or parallel bar
- F. Pencil pointer

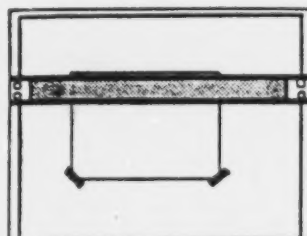
II. Procedure (TM 1.8)

- A. Secure lettering exercise paper to drawing surface with tape
- B. Prepare point of lead for lettering
- C. Hold lead holder in correct position
- D. Study forms and strokes of letters and numerals shown in diagram
- E. Copy letters and numerals on guidelines

NOTE: Use proper form and stroke techniques.

III. Diagram of the procedure

- A. Obtain A size drawing media



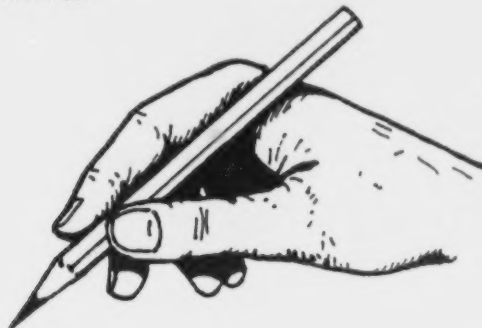
- B. Prepare point of lead

NOTE: Point should be dulled slightly to give desired width of letter elements.



- C. Use correct pencil position

NOTE: Use an even pressure and rotate the lead in the fingers after every few strokes to get uniform lines.



- D. Study form of letters

NOTE: Trace over letters to learn strokes of each letter and numeral.



E. Construct guidelines

NOTE: Space 1/4" apart and copy letters and numerals shown in step D. Use space below for lettering exercise.

CONSTRUCT VERTICAL LOWER-CASE GOTHIC LETTERING

I. Tools and equipment

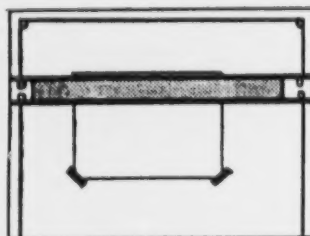
- A. Lead holder or pencil
- B. Drafting tape
- C. Drawing surface
- D. Scale or lettering guide
- E. Drafting machine or parallel bar
- F. Pencil pointer

II. Procedure (AS 1.9)

- A. Secure lettering exercise paper to drawing surface with tape
- B. Prepare point of lead for lettering
- C. Hold lead holder in correct position
- D. Study forms and strokes of letters and numerals shown in diagram
- E. Copy letters and numerals on guidelines using proper form and stroke techniques

III. Diagram of the procedure

- A. Obtain A size drawing media



- B. Prepare point of lead

NOTE: Point should be dulled slightly to give desired width of letter elements.



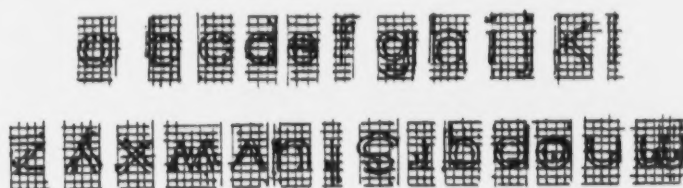
- C. Use correct pencil position

NOTE: Use an even pressure and rotate the lead in the fingers after every few strokes to get uniform lines.



- D. Study form of letters

NOTE: Trace over letters to learn strokes of each letter and numeral.



- E. Construct guidelines

NOTE: Space $\frac{1}{4}$ " apart and copy letters and numerals shown in step D. Use space below for lettering exercise.

CONSTRUCT INCLINED LOWER-CASE GOTHIC LETTERING

I. Tools and equipment

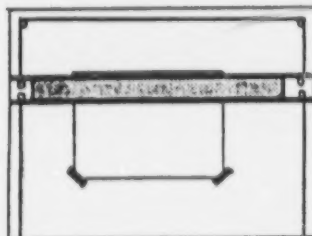
- A. Lead holder or pencil
- B. Drafting tape
- C. Drawing surface
- D. Scale or lettering guide
- E. Drafting machine or parallel bar
- F. Pencil pointer

II. Procedure (TM 1.10)

- A. Secure lettering exercise paper to drawing surface with tape
- B. Prepare point of lead for lettering
- C. Hold lead holder in correct position
- D. Study forms and strokes of letters and numerals shown in diagram
- E. Copy letters and numerals on guidelines using proper form and stroke techniques

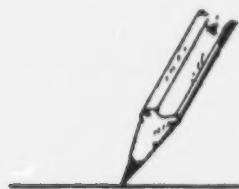
III. Diagram of the procedure

- A. Obtain A size drawing media



- B. Prepare point of lead

NOTE: Point should be dulled slightly to give desired width of letter elements.



- C. Use correct pencil position

NOTE: Use an even pressure and rotate the lead in the fingers after every few strokes to get uniform lines.



- D. Study form of letters

NOTE: Trace over letters to learn strokes of each letter and numeral.



E. Construct guidelines

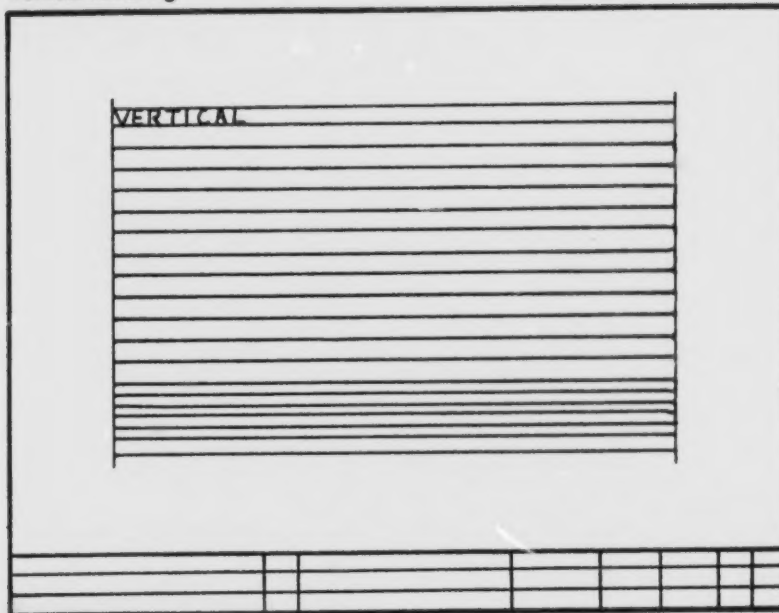
NOTE: Space $\frac{1}{4}$ " apart and copy letters and numerals shown in step D. Use space below for lettering exercise.

PREPARE VERTICAL AND INCLINED LETTERING EXERCISES USING FREEHAND AND MECHANICAL LETTERING DEVICES

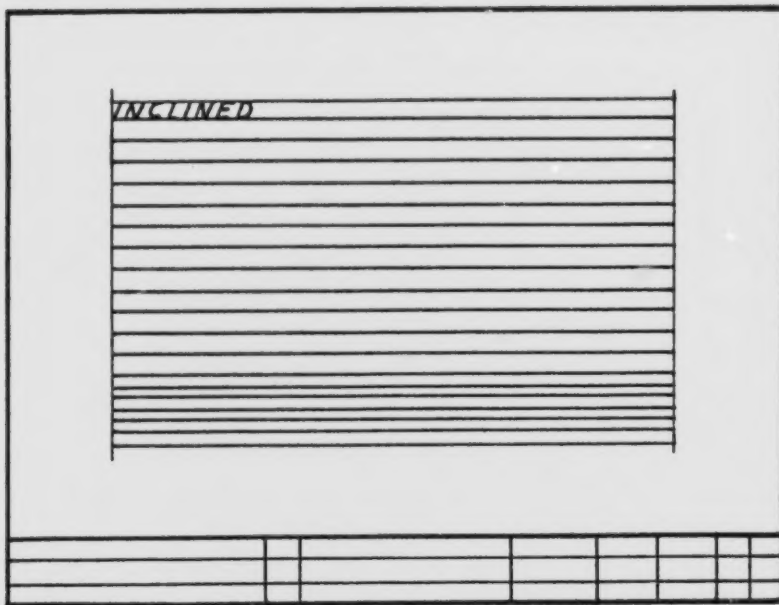
- I. Tools and equipment
 - A. Lead holder or pencil
 - B. Drafting tape
 - C. Drawing surface
 - D. Scale or lettering guide
 - E. Drafting machine or parallel bar
 - F. Pencil pointer
- II. Procedure
 - A. Complete vertical lettering exercise—uppercase
 - 1. Secure A size drawing media to drawing surface and lay out sheet as shown in diagram
 - 2. Use proper form and strokes to complete exercise of vertical letters and numerals as assigned by instructor
 - 3. Use A size media with 1/2" borders; use guidelines as shown
 - B. Complete inclined lettering exercise—uppercase
 - 1. Secure A size drawing media to drawing surface and lay out sheet as shown in diagram
 - 2. Use proper form and strokes to complete exercise of inclined letters and numerals as assigned by instructor
 - 3. Use A size media with 1/2" borders; use guidelines as shown

III. Diagram of the procedure

A. Vertical lettering



B. Inclined lettering



MODULE: CONSTRUCTION TECHNIQUES

UNIT III: LETTERING

UNIT TEST

Mark an "a" for true statements concerning the reasons and rules for neat lettering and a "b" for false statements.

- ☐ 1. Since approximately 60% of the drafter's time is used in lettering, both time and money are saved by the individual or company
- ☐ 2. Lettering can greatly affect the overall appearance of a drawing
- ☐ 3. Although letters must be formed very carefully, skill should be used to letter as much as possible in the limited space
- ☐ 4. When additions or revisions are made to a drawing, the original style of lettering should be matched
- ☐ 5. Most drawings are reproduced, therefore, the lettering must be done with neatness, accuracy, speed, legibility, and be a dense black

Mark an "a" for true statements concerning the procedures for forming letters. Mark a "b" for false statements.

- ☐ 6. Ovals of the letters are formed by a movement of the hand and fingers together
- ☐ 7. The forearm should be at a 90° angle to the area to be lettered, and rest on the drawing board for all lettering movements
- ☐ 8. The vertical or inclined strokes of letters are usually formed by finger and wrist movement
- ☐ 9. The horizontal strokes of lettering are made by a movement of the hand at the wrist along with a very slight finger movement

Mark an "a" for correct statements about the purposes of guidelines and a "b" for incorrect statements.

- ☐ 10. To keep letters spaced properly
- ☐ 11. To improve the overall composition of lettered information
- ☐ 12. To keep letters exactly the same width
- ☐ 13. To maintain correctness in drawing illustrations
- ☐ 14. To keep letters exactly the same height
- ☐ 15. To keep letters positioned in the same direction

Mark an "a" for true statements concerning rules for making guidelines and a "b" for false statements.

- ___ 16. Make vertical guidelines with the aid of a lettering guide
- ___ 17. Align paper and secure corners with tape to working surface
- ___ 18. Horizontal guidelines should be accurately spaced
- ___ 19. Although guidelines are often useful, they are not necessary when a Braddock Rowe triangle is used
- ___ 20. Guidelines should not reproduce

Mark an "a" for true statements concerning rules for spacing and a "b" for false statements.

- ___ 21. The spacing of words is attained by using an imaginary letter "O" as a spacer
- ___ 22. Notes must be placed vertically on the drawing
- ___ 23. Use underline lettering only when special emphasis is needed
- ___ 24. The division line in a common fraction should be parallel to the direction the dimension reads and the numerator and denominator of a fraction should be separated by a 0.06" space
- ___ 25. The spacing between two sentences should always be 1/4"
- ___ 26. Spacing between letters is determined by the area between two letters, not just the distance between two letters
- ___ 27. Each numeral in a fraction should be the same width as a whole number

Distinguish between suggested leads for lettering and those used for constructing guidelines by placing an "a" to the left of those used in lettering and a "b" to the left of those used for constructing guidelines.

- | | | | |
|---------|-----------------------|---------|----|
| ___ 28. | Non-reproducible blue | ___ 32. | 5H |
| ___ 29. | H | ___ 33. | 6H |
| ___ 30. | 2H | ___ 34. | F |
| ___ 31. | 4H | ___ 35. | HB |

Match the name of each lettering instrument on the right with its correct description.

- | | | |
|---------|---|-------------------------------|
| ___ 36. | A machine that produces "Type on tape" | a. Letterguide |
| ___ 37. | An instrument consisting of a template, a scribe, and an inking pen | b. Varsityper |
| ___ 38. | A thin, flat sheet of plastic with letters cut through the sheet | c. Lettering machine |
| ___ 39. | An instrument which uses a one-time carbon ribbon and has a near-standard typewriter keyboard with an open-ended carriage | d. Template |
| ___ 40. | An instrument much like the varigraph which also makes a large variety of styles and sizes of letters | e. Leroy lettering instrument |
| ___ 41. | A device for making a wide variety of either single stroke or "built-up" letters | ab. Varigraph |

Mark an "a" for true statements concerning rules for different types of lettering and a "b" for false statements.

- | | |
|---------|---|
| ___ 42. | In vertical Gothic lettering the number 1 and letter l have no width |
| ___ 43. | In vertical Gothic lettering all numerals except the number one have a width equal to their height |
| ___ 44. | The same rules for letter sizes and spacing that apply in vertical lettering apply in inclined lettering |
| ___ 45. | In inclined Gothic lettering, the letters A, V, W, X, and Y have sloping sides and are difficult to make unless an imaginary inclined center line is used and the letter is drawn symmetrically around it |
| ___ 46. | In vertical Gothic lower-case lettering, the letters p and g terminate without curves on the waist line |
| ___ 47. | The shapes of vertical Gothic lower-case lettering are based on the circle, circular arc, and the straight line |
| ___ 48. | In inclined Gothic lower-case lettering, the letters c, o, s, v, w, x, and z have the same form as their corresponding capitals |

Match the general classes of leads on the right with their uses

- | | | |
|---------|---|-----------------|
| ___ 49. | The softer of these are used for technical sketching, arrowheads, and any freehand work on drawings | a. Hard leads |
| | | b. Medium leads |
| ___ 50. | Wherever extreme accuracy is required | c. Soft leads |
| ___ 51. | Construction lines | |
| ___ 52. | Fine are drawing | |
| ___ 53. | Architectural rendering | |
| ___ 54. | General purpose work | |
| ___ 55. | Lettering, (exclusively) | |
| ___ 56. | Production illustration | |
| ___ 57. | Line work on drawings | |
| ___ 58. | Guidelines for lettering | |

Distinguish between the disadvantages of hard and soft leads by placing an "a" next to the disadvantages of hard leads and a "b" next to the disadvantages of soft leads.

- | | |
|---------|--|
| ___ 59. | Will result in smudged, rough lines |
| ___ 60. | Use is restricted, apt to be too light |
| ___ 61. | Difficult to erase |
| ___ 62. | Must be continually sharpened |

63. Discuss two common problems in lettering stability.

- a.
- b.

ANSWERS TO UNIT III TEST

- | | |
|-------------|-----------------|
| 1. b (C-5) | 22. b (C-5) |
| 2. a (C-5) | 23. a (C-5) |
| 3. b (C-5) | 24. a (C-5) |
| 4. a (C-5) | 25. b (C-5) |
| 5. a (C-5) | 26. a (C-5) |
| 6. a (C-5) | 27. b (C-5) |
| 7. a (C-5) | 28. b (C-5) |
| 8. b (C-5) | 29. a (C-5) |
| 9. a (C-5) | 30. a (C-5) |
| 10. a (C-5) | 31. b (C-5) |
| 11. a (C-5) | 32. b (C-5) |
| 12. b (C-5) | 33. b (C-5) |
| 13. b (C-5) | 34. a (C-5) |
| 14. a (C-5) | 35. a (C-5) |
| 15. a (C-5) | 36. c (C-7) |
| 16. b (C-5) | 37. e (C-7) |
| 17. a (C-5) | 38. d (C-7) |
| 18. a (C-5) | 39. b (C-7) |
| 19. b (C-5) | 40. a (C-7) |
| 20. a (C-5) | 41. ab (C-7) |
| 21. a (C-5) | 42. a (C-5,C-7) |

43. b (C-5,C-7)

44. a (C-5,C-7)

45. a (C-5,C-7)

46. b (C-5,C-7)

47. a (C-5,C-7)

48. a (C-5,C-7)

49. b (C-6)

50. a (C-6)

51. a (C-6)

52. c (C-6)

53. c (C-6)

54. b (C-6)

55. c (C-6)

56. c (C-6)

57. b (C-6)

58. a (C-6)

59. b (C-8)

60. a (C-8)

61. b (C-8)

62. b (C-8)

63. Discussion should include: (C-5,C-7)

- a. On some letters, if the top portion is the same width as the bottom, the letters appear to be top heavy
- b. If the center area of certain letters is placed at midheight to the line, it appears to be below center; therefore, these strokes are placed slightly above the center point of the letters B, E, F, and H

MODULE: CONSTRUCTION TECHNIQUES

UNIT IV: GEOMETRIC CONSTRUCTIONS

UNIT OBJECTIVES

After completion of this unit, the student should be able to match basic geometric terminology with correct definitions, match basic geometric shapes with their descriptions, and identify basic geometric shapes. The student should also be able to measure a circle and interpret the degrees in it, and construct basic geometric forms. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring ____ percent on the unit test.

OBJECTIVES

After completion of this unit, the student should be able to:

- 1.1 Match basic geometric terms with their correct definitions.
- 1.2 Match types of angles with their correct descriptions.
- 1.3 Match types of triangles with their correct descriptions
- 1.4 Match circular shapes with their correct descriptions.
- 1.5 Match four-sided shapes, cones, and special figures with their correct descriptions.
- 1.6 Match polygons and diagonals with their correct descriptions.
- 1.7 Identify basic geometric shapes.
- 1.8 Match geometric terms with their correct symbols.
- 1.9 List three elements needed for measuring parts of a circle.
- 1.10 List three elements needed for interpreting degrees in a circle.
- 1.11 Demonstrate the ability to:
 - a. Bisect a line and an arc.
 - b. Bisect an angle.
 - c. Draw parallel lines.
 - d. Construct a perpendicular line to a line from a point.
 - e. Divide a line into equal parts.
 - f. Draw a line perpendicular through a point on a line.
 - g. Draw an arc tangent to a straight line and an arc.
 - h. Draw an arc tangent to two arcs.

- i. Construct a triangle with sides given.
- j. Construct a right triangle.
- k. Construct an equilateral triangle with one side given.
- l. Inscribe a hexagon inside a circle.
- m. Construct a hexagon with the distance across the flat sides given.
- n. Construct a circle through three given points.
- o. Construct a pentagon by inscribing.
- p. Draw an arc tangent to an acute angle and an obtuse angle.
- q. Draw an arc tangent to a right angle.
- r. Draw an involute of a circle.
- s. Draw an ellipse using the approximate ellipse with compass method.
- t. Draw a parabola.
- u. Join two points with a parabolic curve.

MODULE: CONSTRUCTION TECHNIQUES

UNIT IV: GEOMETRIC CONSTRUCTIONS

CONTENTS OF THIS UNIT

- A. Objective sheets
- B. Notes to the instructor
- C. References
- D. Lesson 1: Geometric Constructions
 - a. Information outline
 - b. Transparency masters
 - TM 1.1: Basic Geometric Shapes and Terms
 - TM 1.2: Basic Geometric Shapes and Terms (Continued)
 - TM 1.3: Types of Angles
 - TM 1.4: Types of Triangles
 - TM 1.5: Circular Shapes
 - TM 1.6: Circular Shapes (Continued)
 - TM 1.7: Circular Shapes (Continued)
 - TM 1.8: Four-sided Shapes, Cones, and Special Figures
 - TM 1.9: Special Figures
 - TM 1.10: Quadrilaterals
 - TM 1.11: Solids
 - TM 1.12: Involutess
 - TM 1.13: Involute of a Circle
 - TM 1.14: Polygons and Diagonals
 - TM 1.15: Polygons
 - c. Assignment sheets
 - AS 1.1: Bisect a Line and an Arc
 - AS 1.2: Bisect an Angle and Draw Parallel Lines
 - AS 1.3: Construct a Perpendicular Line to a Line from a Point and Draw a Line Perpendicular Through a Point on a Line
 - AS 1.4: Construct a Triangle and a Right Triangle with Sides Given
 - AS 1.5: Construct an Equilateral Triangle with One Side Given
 - AS 1.6: Inscribe a Hexagon Inside a Circle and Construct a Hexagon with the Distance Across the Flat Sides Given
 - AS 1.7: Construct a Pentagon by Inscribing
 - AS 1.8: Draw Ellipses Using The Approximate Ellipse with Compass Method
 - AS 1.9: Draw an Arc Tangent to a Straight Line and an Arc
 - AS 1.10: Draw an Arc Tangent to Two Arcs
 - AS 1.11: Draw an Arc Tangent to an Acute Angle and an Obtuse Angle
 - AS 1.12: Draw an Arc Tangent to a Right Angle
 - AS 1.13: Divide a Line into Equal Parts
- E. Unit test
- F. Answers to unit test

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2. Davis, Ronald, Bill Hill and Bruce Yancey. Basic Drafting: Book Two. Stillwater, Okla. 74074: Mid-America Vocational Curriculum Consortium, Inc., 1981.
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8. Wallach, Paul Ross. Drafting Problems. 2nd ed. Mission Hills, Calif. 91345: Glencoe Publishing Co., 1988.
9. Wallach, Paul Ross and Dean Chowenhill. Drafting in a Computer Age. Albany, N.Y. Delmar Publishers, Inc., 1989.

NOTES TO THE INSTRUCTOR

- A. Suggested approaches to teaching this unit
 1. Have students make models of some geometric shapes.
 2. Select title block you want to be used in AS 1.10.

MODULE: CONSTRUCTION TECHNIQUES
UNIT IV: GEOMETRIC CONSTRUCTIONS
LESSON 1: GEOMETRIC CONSTRUCTIONS

I. Basic geometric terms and definitions

- A. **Point**—a small dot or small cross on a drawing or in space that does not have length, height, depth, or width (TM 1.1)
- B. **Line**—a connection between two or more points (TM 1.1)
- C. **Straight line**—the shortest distance between two points (TM 1.1)
- D. **Curved line**—a line in which no segment is straight (TM 1.1)
- E. **Line segment**—any part of a line (TM 1.1)
- F. **Plane figure**—a flat, level, even surface such as a piece of paper lying flat on a table (TM 1.1)

NOTE: This is sometimes referred to simply as a plane.

- G. **Intersect**—to cut across each other (TM 1.1)
- H. **Vertex**—the common point where lines or surfaces intersect (TM 1.1)
- I. **Perpendicular**—at 90° angles to a given plane or line (TM 1.1)
- J. **Parallel**—straight lines that do not meet or intersect and are an equal distance apart at all points (TM 1.1)
- K. **Projection line**—line used to extend from one view to another view (TM 1.1)
- L. **Skew (oblique) lines**—straight lines that do not intersect and are not parallel or in the same plane (TM 1.2)
- M. **Bisect**—to divide into two equal parts (TM 1.2)
- N. **Vertical**—a line straight up and down perpendicular to the horizontal plane (TM 1.2)
- O. **Horizontal**—parallel to the plane of the horizon (TM 1.2)
- P. **Edge**—what appears as a line when a plane surface is perpendicular to a plane of projection (TM 1.2)
- Q. **Equilateral**—all sides are equal

II. Types of angles and descriptions (TM 1.3)

- A. **Angle**—figure formed by two intersecting lines
- B. **Straight line**— _____

- C. **Right angle**--a 90° angle
- D. **Acute angle**--an angle less than 90°



- E. **Obtuse angle**--an angle greater than 90°



- F. **Complementary angles**--two angles whose sum is 90°
- G. **Supplementary angles**--two angles whose sum is 180°

III. Types of triangles and descriptions (TM 1.4)

- A. **Triangle**--a plane figure bound by three straight sides, and three interior angles which equal 180°
- B. **Equilateral triangle**--a triangle with three equal sides and three equal angles



- C. **Isosceles triangle**--a triangle with two equal sides and two equal angles



- D. **Scalene triangle**--a triangle with no angles or sides equal



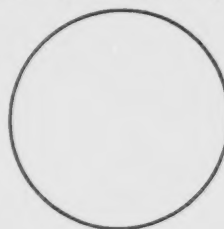
- E. **Right triangle**—a triangle with one 90° angle

NOTE: The side opposite the 90° angle of a right triangle is the hypotenuse.



IV. Circular shapes and descriptions

- A. **Circumference**—the distance around a circle (TM 1.5)
- B. **Radius**—the distance from the center point of a circle to the outside circumference (TM 1.5)
- C. **Diameter**—the distance across a circle passing through its center point (TM 1.5)
- D. **Circle**—a closed curve all points of which are an equal distance from the center (TM 1.5)



- E. **Arc**—any portion of the circumference of a circle (TM 1.5)
- F. **Sphere**—a round body such as a ball which has all points of its circumference an equal distance from its center (TM 1.5)



- G. **Concentric circles**—having the same point as center (TM 1.5)
- H. **Eccentric circles**—having different points as center, one within the other (TM 1.5)
- I. **Symmetrical**—the same on both sides of a center line (TM 1.6)
- J. **Inscribed**—a figure drawn within another figure so as to touch in as many places as possible (TM 1.6)
- K. **Circumscribed**—a figure constructed around a figure so as to touch as many points as possible

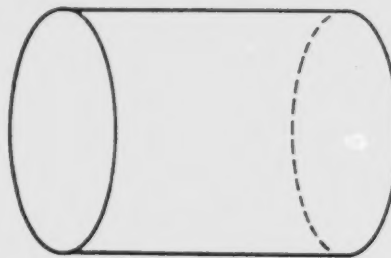
- L. **Axis**--a straight line passing through the center of a geometric body upon which the geometric body rotates (TM 1.6)
- M. **Torus**--a solid figure generated by a circle which is revolving on an axis which is eccentric to the circle (TM 1.6)



- N. **Ellipse**--a foreshortened circle having a major diameter and a minor diameter (TM 1.6)



- O. **Cylinder**--a solid figure generated by a straight line moving in contact with a curved line and always remaining parallel to its previous position or to the axis (TM 1.6)



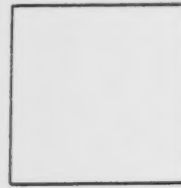
- P. **Tangent**--meeting a curved line or surface, touching at one and only one point, but most definitely not intersecting (TM 1.7)

NOTE: To make better tangencies, draw the circular object first, when possible; then draw the straight line from it.

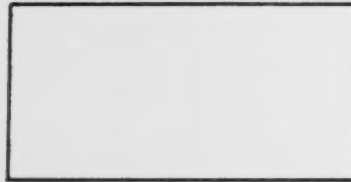
- Q. **Chord**--any straight line across a circle that does not pass through the center
- R. **Semicircle**--one-half of the circle
- S. **Circular segment**--less than a semicircle
- T. **Quadrant**--one-fourth of a circle
- U. **Sector**--less than a quadrant

V. Four-sided shapes, cones, and special figures and descriptions

- A. **Square**—a plane figure bound by four equal sides, and having four 90° angles (Equilateral parallelogram (TM 1.8))



- B. **Rectangle**—a plane figure bound by parallel sides of different lengths to form opposite sides that are equal, and having four 90° angles (TM 1.8)



- C. **Cone**—a solid figure with a circle as its base, and a curved surface tapering evenly to the vertex, so that any point on the surface is in a straight line between the circumference of the base and the vertex (TM 1.8)



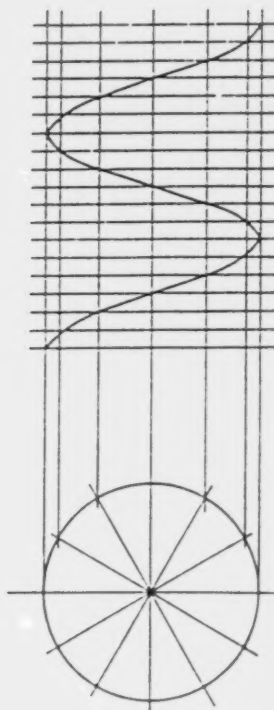
- D. **Conic sections**—curves produced by a plane when it intersects a right circular cone (TM 1.8)

NOTE: Types of curves produced are the circle, ellipse, hyperbola, and parabola.

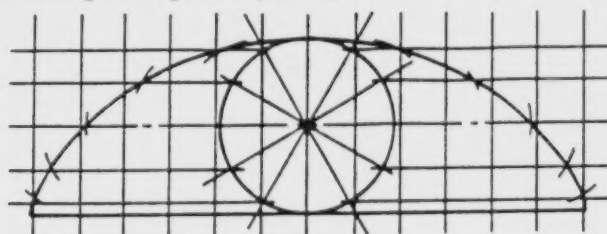
- E. **Parabola**--a curve generated by a point moving so that its distance from a fixed point is equal to its distance from a fixed line (TM 1.8)



- F. **Helix**--generated by a point moving along and around the surface of a cone or cylinder with a uniform angular velocity about the axis, and with a uniform linear velocity in the direction of the axis (TM 1.9)



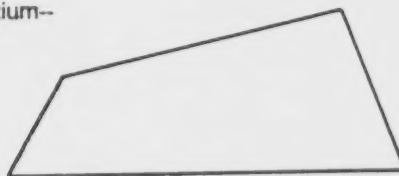
- G. **Cycloid**—a curve generated by a point located on the circumference of a circle as the circle rolls along a straight line (TM 1.9)



- H. **Quadrilateral**—a plane figure bound by four straight sides (TM 1.10)

Quadrilaterals

1. Rectangle
2. Square
4. Trapezium--



5. Trapezoid--



- I. **Parallelogram**—a plane figure bound by four straight sides with the opposite sides parallel (TM 1.10)

Parallelograms

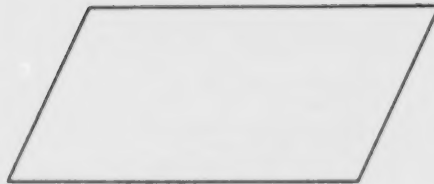
1. Equilateral
 - a. Square--



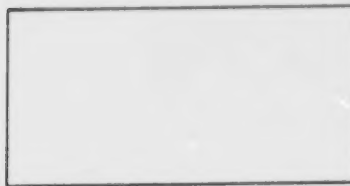
- b. Rhombus--



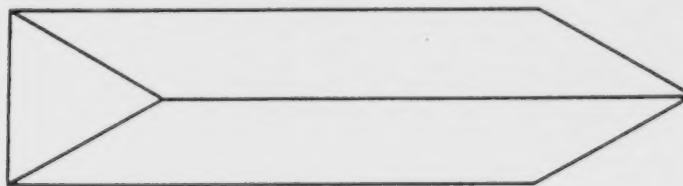
2. Rhomboid--



3. Rectangle--



- J. **Prism**--a solid figure whose plane bases are parallel equal polygons and whose faces are parallelograms (TM 1.11)



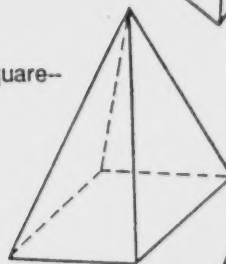
- K. **Pyramid**--a solid figure with a polygon for a base, with triangular lateral faces that intersect at a common point called a vertex (TM 1.11)

Pyramids

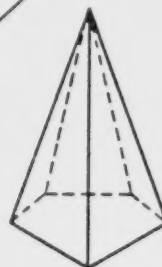
1. Right triangular--



2. Right square--



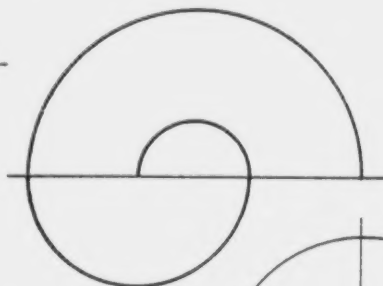
3. Pentagonal--



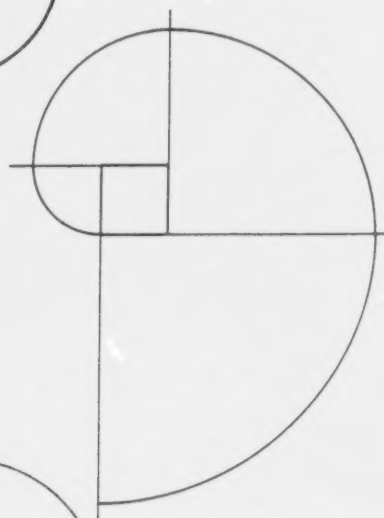
L **Involute**—a curve traced by a point on a thread or string, as the thread or string unwinds from a line (TMs 1.12 and 1.13)

Involutes

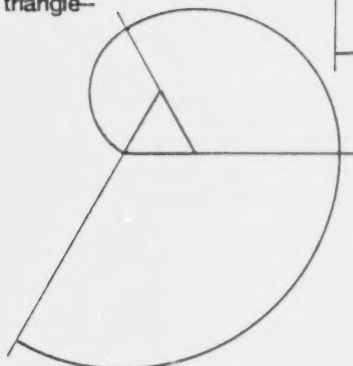
1. Involute of a line—



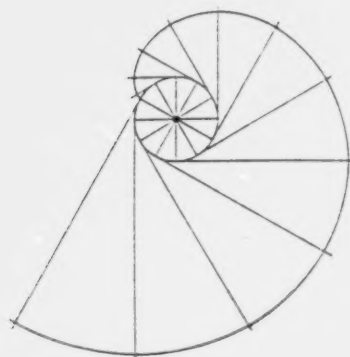
2. Involute of a square—



3. Involute of a triangle—

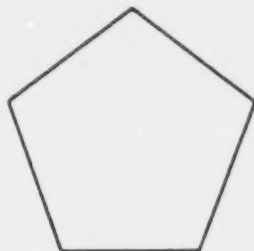


4. Involute of a circle—

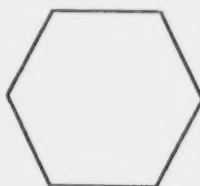


VI. Polygons and diagonals and descriptions (TMs 1.14 and 1.15)

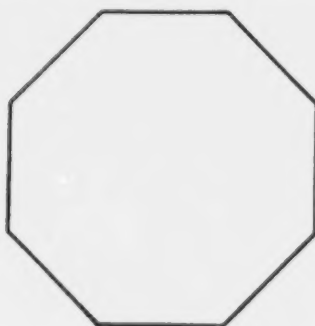
- A. **Polygon**--a plane figure with more than three straight sides
- B. **Diagonals**--lines connecting opposite nonsymmetrical corners of a polygon
- C. **Regular polygon**--a plane figure with equal straight sides and equal angles; it can be circumscribed around, or inscribed in a circle
- D. **Pentagon**--a polygon that has five equal sides and five equal angles



- E. **Hexagon**--a polygon that has six equal sides and six equal angles



- F. **Octagon**--a polygon that has eight equal sides and eight equal angles



VII. Geometric terms and symbols

A. Perpendicular-- $\perp$

B. Parallel-- $\parallel$

C. Angle (singular)-- $\angle$

D. Angles (plural)-- $\angle$ s

E. Less than-- $<$

F. Greater than-- $>$

G. Diameter-- $\ominus$

H. Radius-- R

VIII. Three elements needed for measuring parts of a circle

- Diameter is measured on a straight line passing through the center point of the circle and extending to the circumference
- Radius is measured on a straight line from the center of the circle to any point on the circumference; equals one-half the diameter
- Circumference is measured by multiplying the diameter of the circle by π (3.1415926 or 3.14)

IX. Three elements needed for interpreting degrees in a circle

- A full circle has 360 degrees, written as 360°
- Each degree is divided into 60 minutes, written as $60'$
- Each minute is divided into 60 seconds, written as $60''$

Example: $52^\circ 14' 5''$ would be read as fifty-two degrees, 14 minutes, 5 seconds

X. Bisect a line and an arc

Premise: A line and an arc can be bisected with a triangle and compass by using the procedure in the following example.

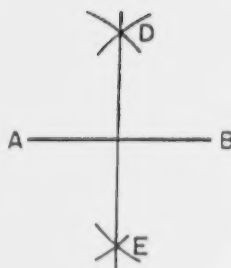
Example:

- Use given line AB 

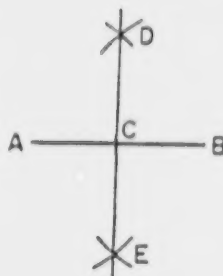
- From A and B use compass to draw equal arcs crossing above and below given line with radius greater than half of AB



3. Join points D and E with a line



4. Mark point at C

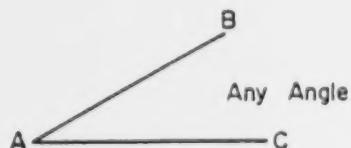


XI. Bisect an angle

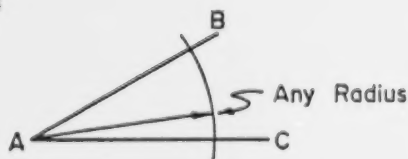
Premise: An angle can be bisected with a triangle and compass by using the procedure in the following example.

Example:

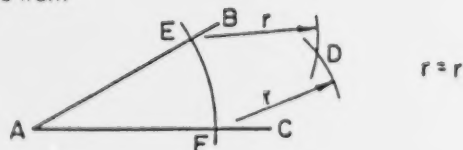
1. Use given angle BAC



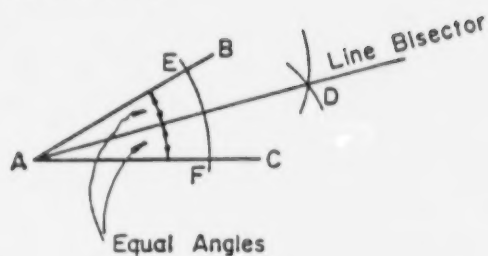
2. Strike a radius using a compass at any radius with vertex A as the center point



3. Strike equal arcs r with radius larger than half the distance from E to F



4. Draw a line from arc intersection
D to vertex A



XII. Draw parallel lines

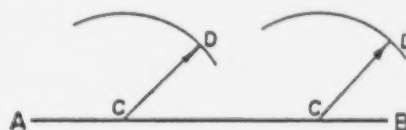
Premise: Parallel lines can be drawn with a triangle and compass by using the procedure in the following example.

Example:

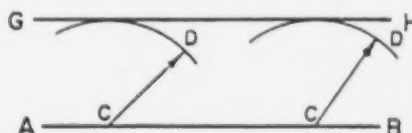
1. Use given line AB



2. Set compass any desired radius CD and swing two arcs anywhere along AB



3. Construct line GH tangent to arcs CD (radius CD required distance between parallel lines)



XIII. Construct a circle through three given points

Premise: A circle can be constructed through three given points with a triangle and compass by using the procedure in the following example.

Example:

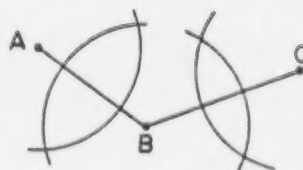
1. Use given points A, B, and C which are not in a straight line



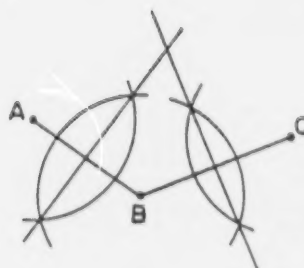
2. Connect lines AB and BC



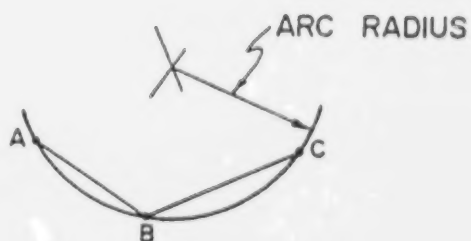
3. Find perpendicular bisectors of lines AB and BC; swing arcs as shown



4. Extend bisector lines until they intersect; this will be center point of circle



5. Use this point as center of circle radius

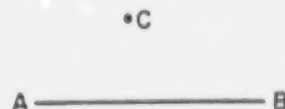


XIV. Construct a perpendicular line to a line from a point

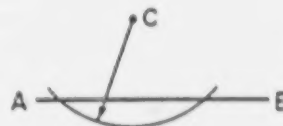
Premise: A perpendicular line can be constructed to a line from a point with a triangle and compass by using the procedure in the following example.

Example:

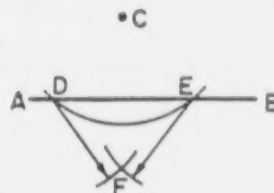
1. Use given line AB and point C



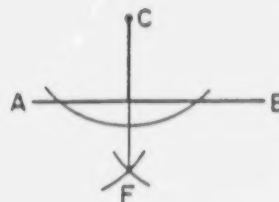
2. Swing any radius from point C as long as it touches two points on line AB



3. Swing radius DF and radius EF at any radius greater than half of DE



4. Connect point C with point F
(NOTE: Line C-F is 90° to A-B)

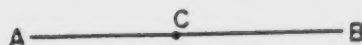


XV. Draw a line perpendicular through a point on a line

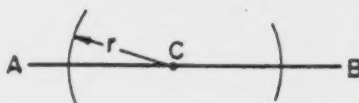
Premise: A line can be drawn perpendicularly through a point on a line with a triangle and compass by using the procedure in the following example.

Example:

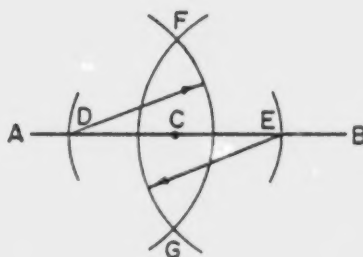
1. Use given line AB with point C located on line AB



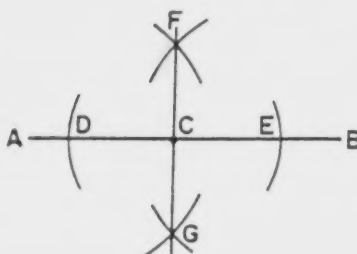
2. Set compass at any radius r and swing arc through line AB from point C



3. Set compass at distance greater than DC and swing arcs from D and E to form points F and G



4. Connect points F and G through C

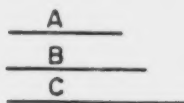


XVI. Construct a triangle with sides given

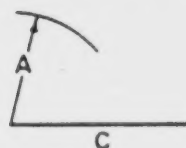
Premise: A triangle can be constructed with sides given with a triangle and compass by using the procedure in the following example.

Example:

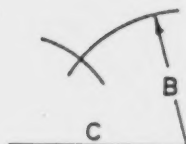
1. Use given sides A, B, and C



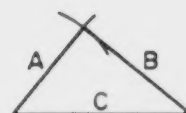
2. Draw one side, the length of C, in desired position, and strike arc with radius equal to given side A



3. Strike arc with radius equal to given side B



4. Draw sides A and B from intersection of arcs, as shown

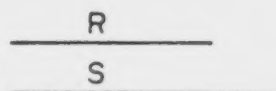


XVII. Construct a right triangle

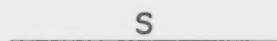
Premise: A right triangle can be constructed with a triangle and compass by using the procedure in the following example.

Example:

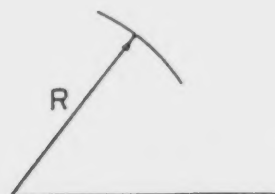
1. Use given sides R and S



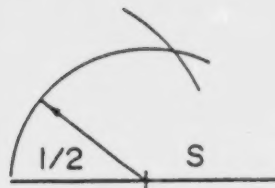
2. Draw line S with triangle



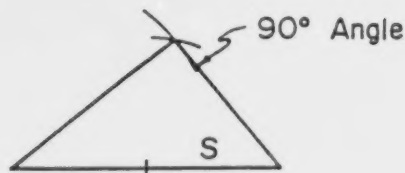
3. Swing arc with radius length as R



4. Find the middle of line S and use that point with radius $1/2$ length of S to swing arc



5. At point of arc intersection connect to end points of line S as shown



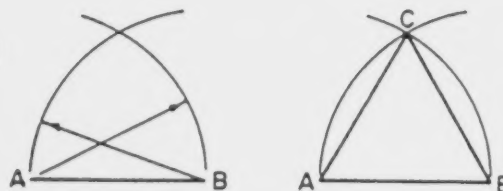
XVIII. Construct an equilateral triangle with one side given

Premise: An equilateral triangle with one side can be constructed with a 30° 60° triangle or compass by using the procedure in the following example.

Example:

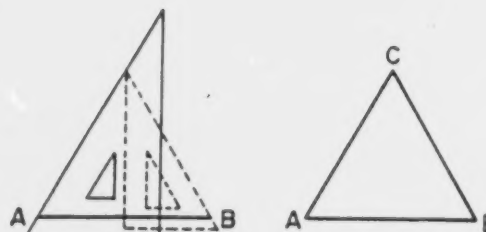
1. Compass method

- a. With A and B as centers and AB as radius, strike arcs to intersect at C



- b. Draw lines AC and BC to complete the triangle

2. Triangle method--use 60° triangle to right of A and left of B to intersect at C



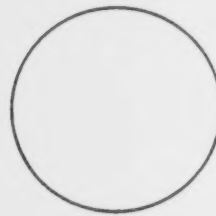
Note: triangle is parallel to line AB

XIX. Inscribe a hexagon inside a circle

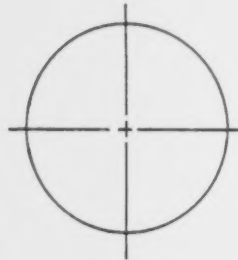
Premise: A hexagon can be inscribed inside a circle with a $30^\circ 60^\circ$ triangle by using the procedure in the following example.

Example:

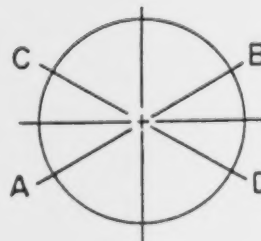
1. Use given circle diameter equal to required distance across corners of hexagon



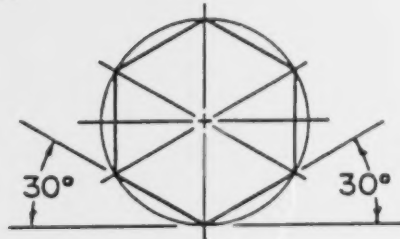
2. Draw vertical and horizontal center lines through circle



3. Use 30° triangle to construct diagonals AB and CD at 30° with horizontal through center point



4. Use 30° triangle to construct sides

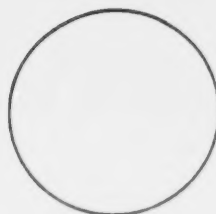


XX. Construct a hexagon with the distance across the flat sides given

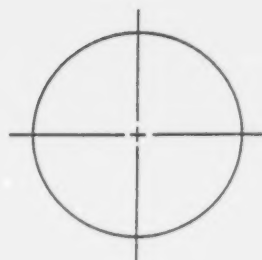
Premise: A hexagon with the distance across the flat sides given can be constructed with a $30^\circ 60^\circ$ triangle, compass, and parallel bar or drafting machine by using the procedure in the following example.

Example:

1. Use given circle diameter or distance across hexagon flats (1 3/16")

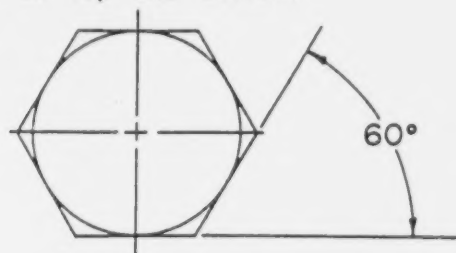


2. Put in vertical and horizontal center lines

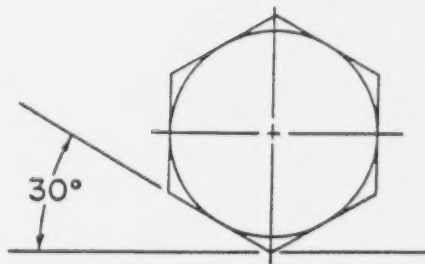


Flats on top and bottom

3. With the 30° 60° triangle and parallel bar or drafting machine, draw the six sides tangent to the circle; flats can be on sides or on top and bottom



Flats on sides

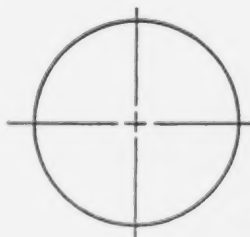


XXI. Construct a pentagon by inscribing

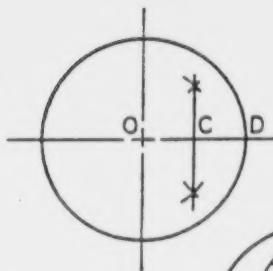
Premise: A pentagon can be constructed with a triangle and compass by using the inscribing procedure in the following example.

Example:

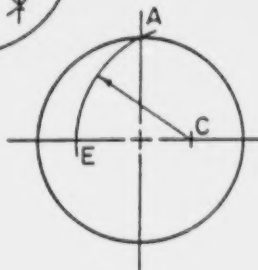
1. Use given circle



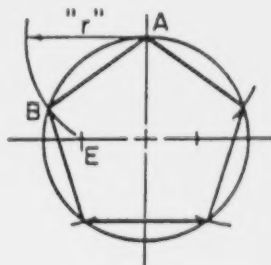
2. Bisect radius OD at C



3. With C as center and CA as radius, strike arc AE



4. With A as center and AE as radius, strike arc EB
5. Draw line AB; then set off distances AB around the circumference of the circle using compass and draw the sides through the points



XXII. Draw an ellipse using the approximate ellipse with compass method

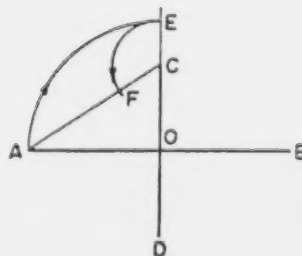
Premise: An ellipse can be drawn by the compass method with a triangle, compass, and parallel bar or drafting machine by using the procedure in the following example.

Example:

1. Use given axis AB and axis CD

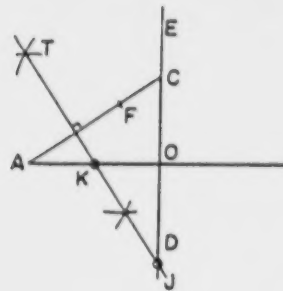


2. Draw line AC
3. With O as center and OA as radius, strike arc AE
4. With C as center and CE as radius, strike the arc EF

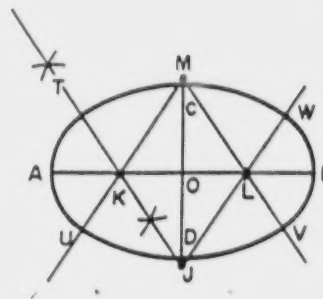


5. Draw perpendicular bisector of the line AF; the points K, and J where it intersects the axes, are centers of the required arcs

(NOTE: If needed, refer to Assignment Sheet #1 for drawing a perpendicular bisector of a line.)



6. Find center M by measuring OJ with compass
7. Set compass point at O and strike point M
8. Find center L by measuring OK with compass
9. Set compass point at O and strike point L
10. Draw line M through point K to form point U
11. Draw line M through point L to form point V
12. Draw line J through point L to form point W
13. Keep arcs tangent as shown
14. Using K as the center point, swing arc KA from point U to point T
15. Using L as the center point, swing arc LB from point W to point V
16. Using M as the center point, swing arc MD from point V to point U
17. Using J as the center point, swing arc JC from point T to point W

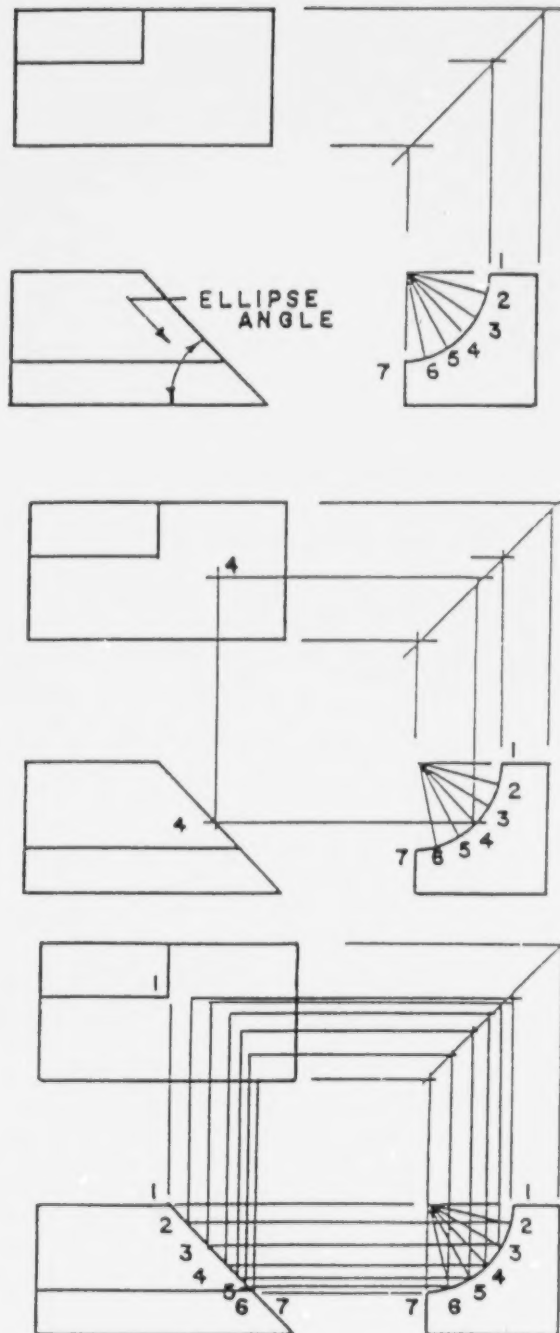


XXIII. Draw an elliptical curve

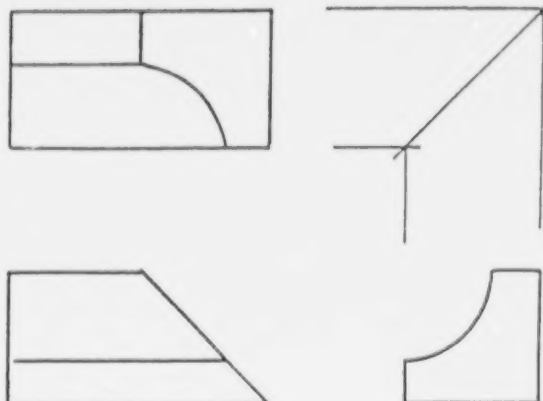
Premise: The intersection of a hole or cylinder with an inclined plane will be shown as an ellipse or elliptical curve. Ellipses can be constructed with templates or by hand. Ellipse templates are available in ellipse angles at 5° intervals, such as 15° , 20° , 25° . If an ellipse template is not available, use the procedure in the following example:

Example:

1. Construct the three views showing circle or curve and angle of inclined plane
2. Divide the curve into an equal random number of points
(NOTE: Several points are needed for a smooth curve.)
3. Project point marked No. 4 on curve to other views to intersect in top view
4. Project the other marked points to intersect, representing inclined edge
5. Sketch a light curved line through the intersection of points



6. Erase construction lines and darken in curve line with the aid of an irregular curve

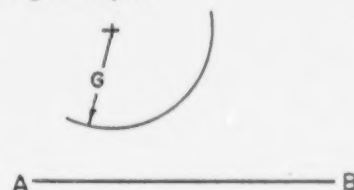


XXIV. Draw an arc tangent to a straight line and an arc

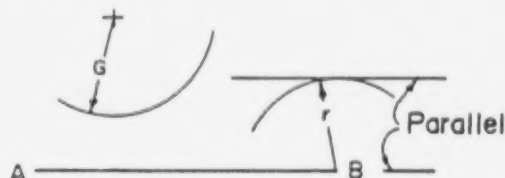
Premise: An arc tangent can be drawn to a straight line and an arc with a triangle and compass by using the procedure in the following example.

Example:

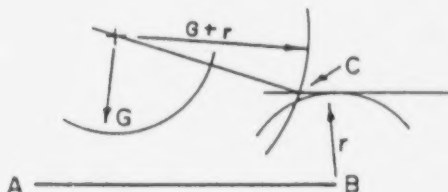
1. Use given arc with radius G and straight line AB



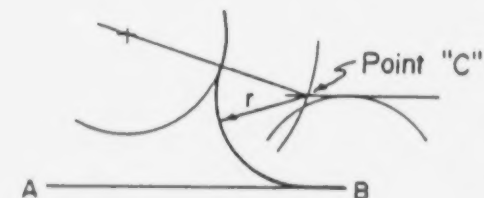
2. Swing given arc r from point B and draw a parallel line tangent to arc r



3. Add radius G to radius r and swing arc $G+r$ to point C from point D



4. Draw line from the center point of radius G and $G+r$ to point C to obtain tangency point



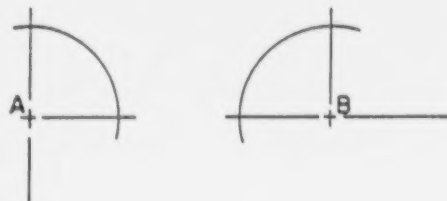
5. With center C and given radius r , draw required tangent arc between the line AB and arc

XXV. Draw an arc tangent to two arcs

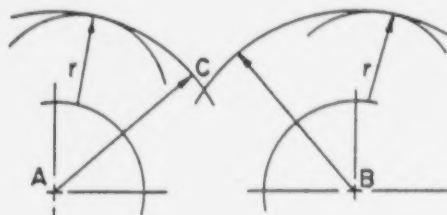
Premise: An arc tangent can be drawn to two arcs with a triangle and compass by using the procedure in the following example.

Example:

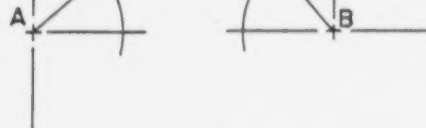
1. Use given arcs with centers A and B, and required radius r



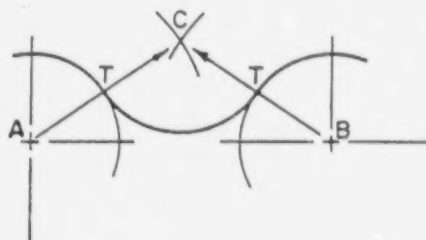
- a. Swing arcs r using any point on circles as center point



- b. Swing arc AC and arc BC tangent to given arcs



2. Draw lines of centers AC and BC to locate points of tangency T, and draw required tangent arc between the points of tangency, as shown from center C



XXVI. Draw an arc tangent to an acute angle and an obtuse angle

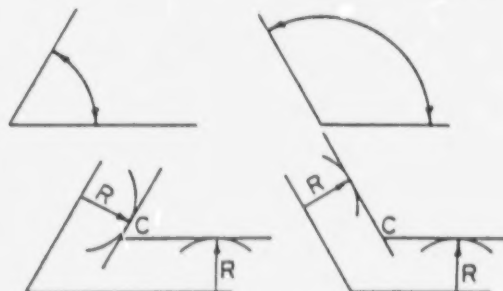
Premise: An arc tangent can be drawn to an acute angle and an obtuse angle with a triangle, compass, and parallel bar or drafting machine by using the procedure in the following example.

Example:

1. Use given acute angle and obtuse angle

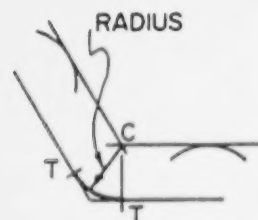
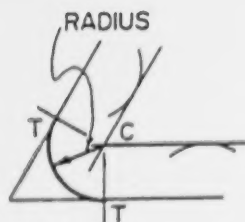
NOTE: In this example every step will be performed on the acute angle on the left and on the obtuse angle on the right.

ACUTE ANGLE OBTUSE ANGLE

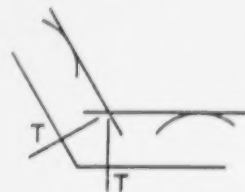
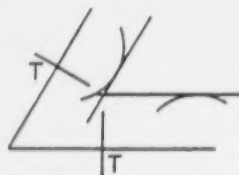


2. Draw lines parallel to given lines at distance R from them, to intersect at C, the required center

3. From C drop perpendiculars to the given lines respectively to locate points of tangency T



4. With C as center and with given radius R, draw required tangent arc between the points of tangency



XXVII. Draw an arc tangent to a right angle

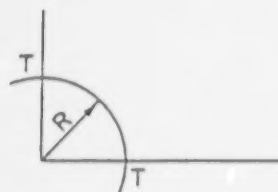
Premise: An arc tangent can be drawn to a right angle with a triangle by using the procedure in the following example.

Example:

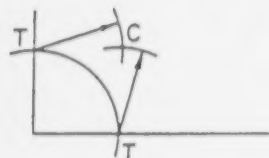
1. Use given lines at right angles to each other



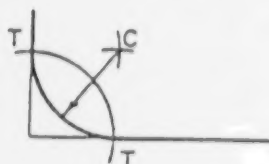
2. With given radius R, strike arc intersecting given lines at tangent points T



3. With given radius R again, and with points T as centers, strike arcs intersecting at C



4. With C as center and given radius R, draw required tangent arc



XXVIII. Divide a line into equal parts

Premise: A line can be divided into equal parts with a 45° and 30° 60° triangle and a scale by using the procedure in the following example.

Example:

1. Use given line AB to divide into five equal parts



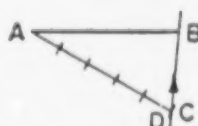
2. Draw a line at any angle and any length and label point C



3. Use scale to lay off five equal divisions on line AC; label the last division D



4. Set triangle to project division back to line AB from point D

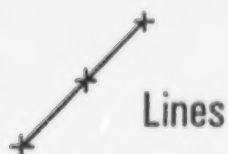


5. Set triangles to be parallel to line BD; mark divisions on line AB parallel to line BD

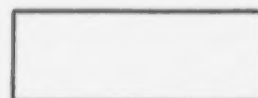


Basic Geometric Shapes and Terms

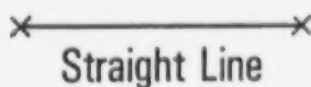
• +
Point



Lines



Plane Figure



Straight Line



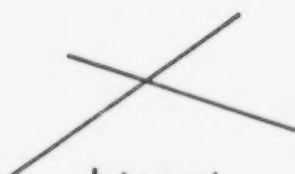
Curved Line



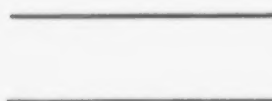
Line Segments



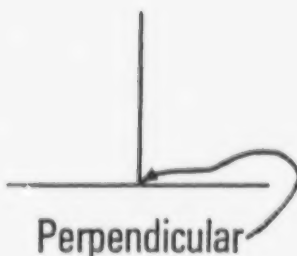
Vertex



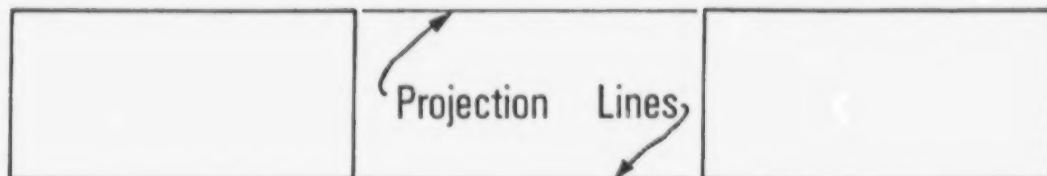
Intersect



Parallel

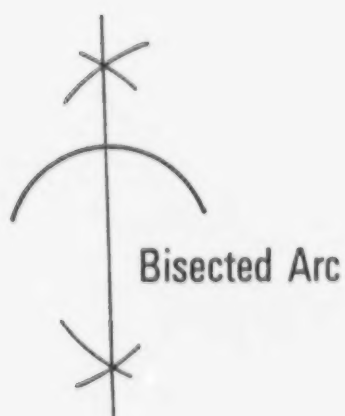
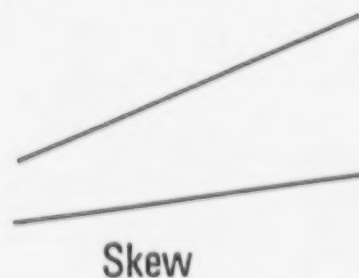
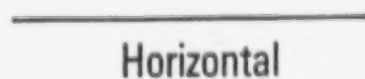
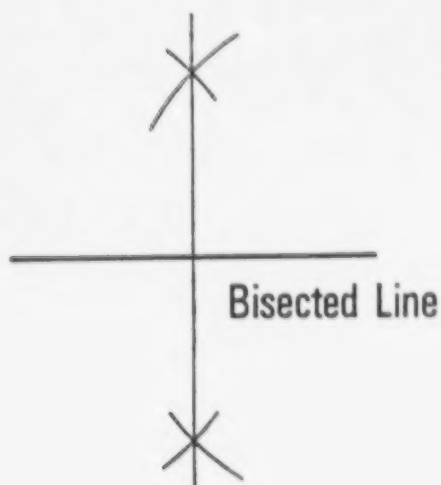
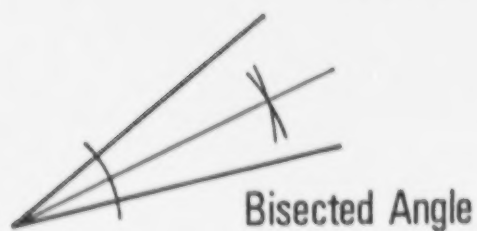


Perpendicular

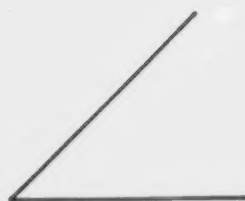


Basic Geometric Shapes & Terms

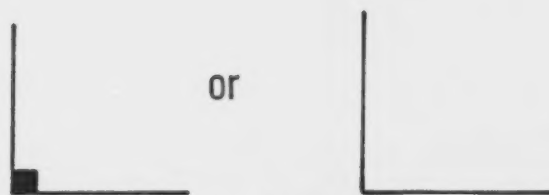
(Continued)



Types of Angles



Angle



or

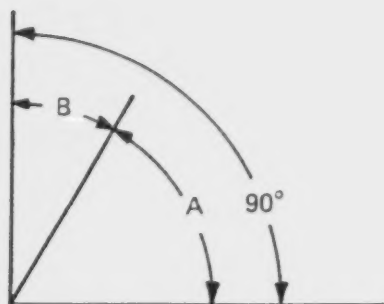
Right Angle



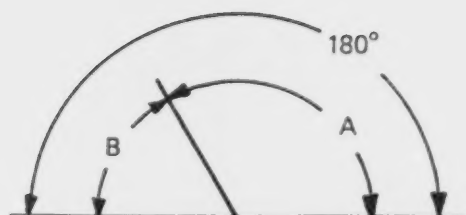
Acute Angle



Obtuse Angle



Complementary Angles



Supplementary Angles

Types of Triangles



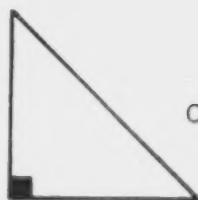
Equilateral Triangle



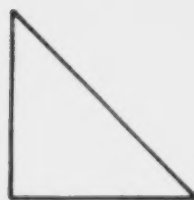
Isosceles Triangle



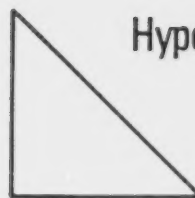
Scalene Triangle



OR

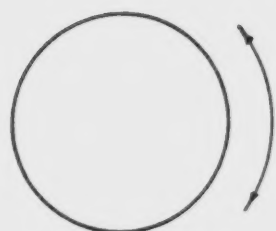


Right Triangle

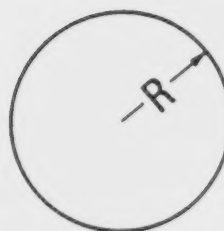


Hypotenuse

Circular Shapes



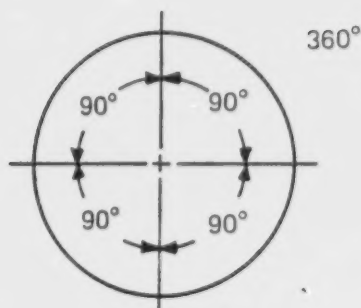
Circumference



Radius



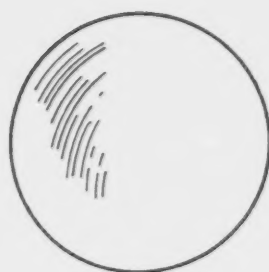
Diameter



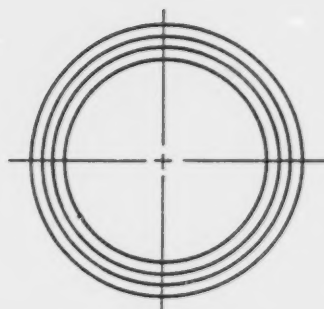
Circle



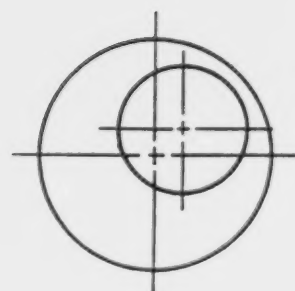
Arc



Sphere

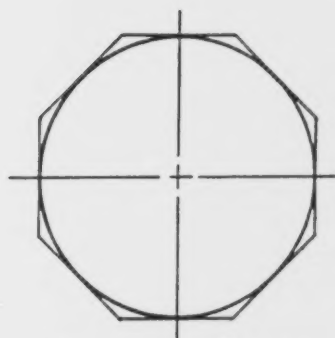


Concentric Circles



Eccentric Circles

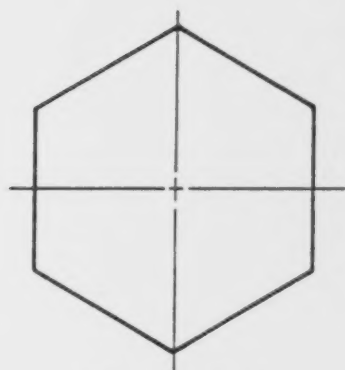
Circular Shapes (Continued)



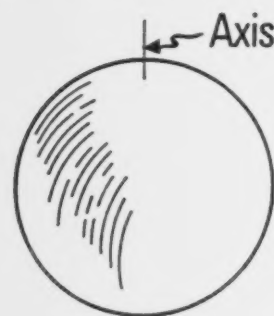
Inscribed Circle



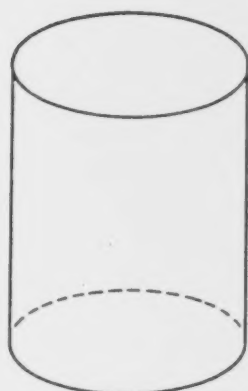
Circumscribed Circle



Symmetrical



Axis



Cylinder



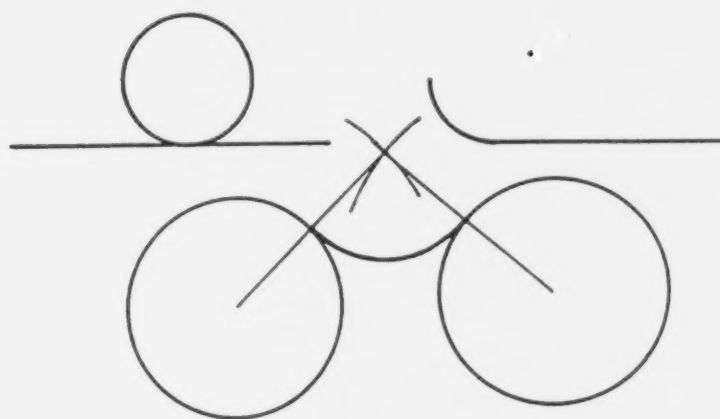
Torus



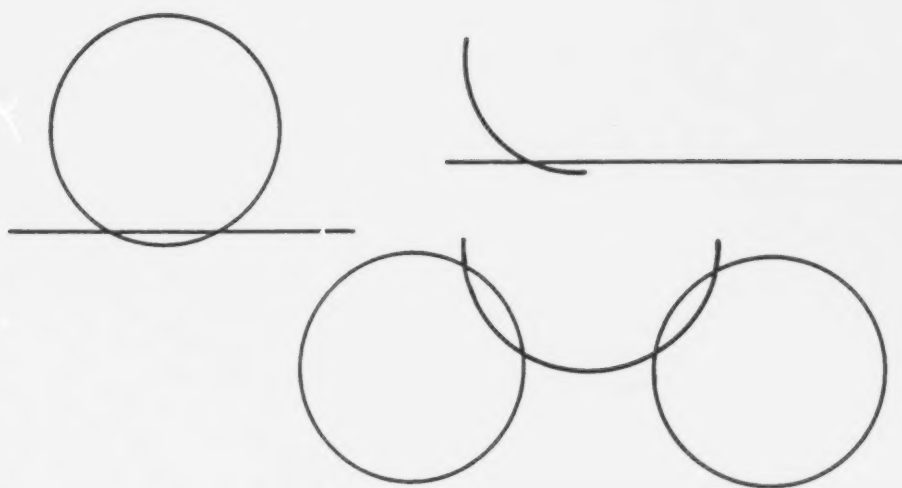
Ellipse

Circular Shapes

(Continued)

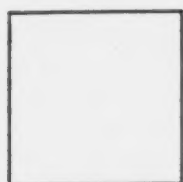


Tangent

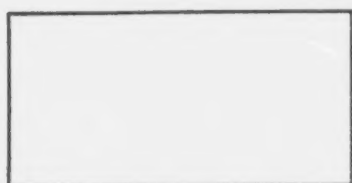


Not Tangent

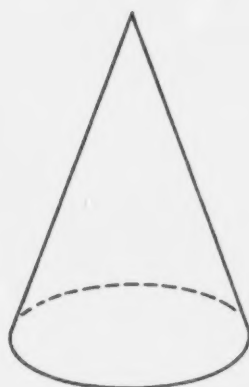
Four-Sided Shapes, Cones, and Special Figures



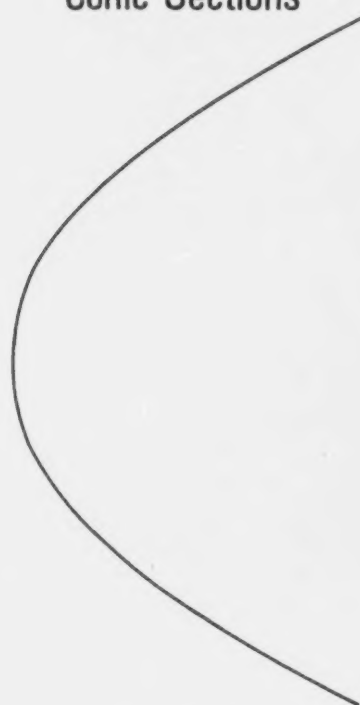
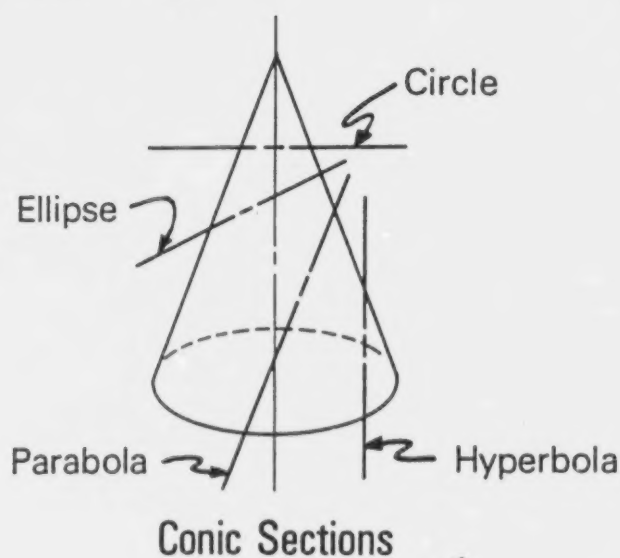
Square



Rectangle

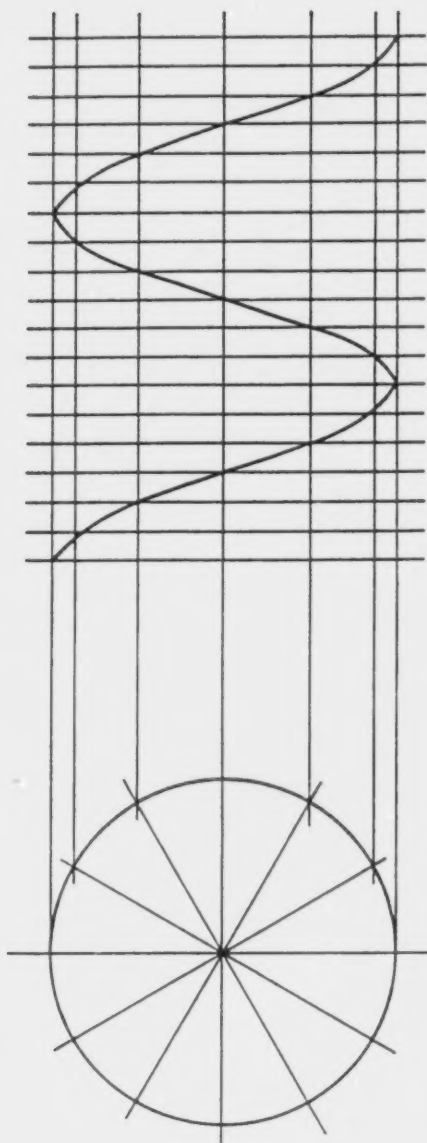


Cone

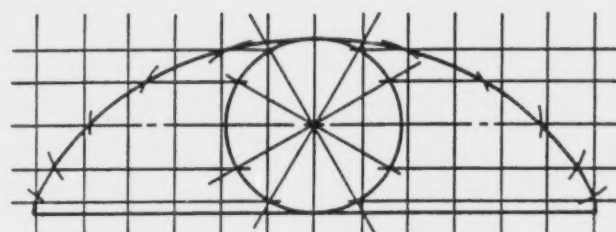


Parabola

Special Figures



Helix



Cycloid

Quadrilaterals

(TWO SIDES PARALLEL)



Trapezoid

(NO SIDES PARALLEL)



Trapezium

Parallelograms

Equilateral Parallelograms



Square



Rhombus

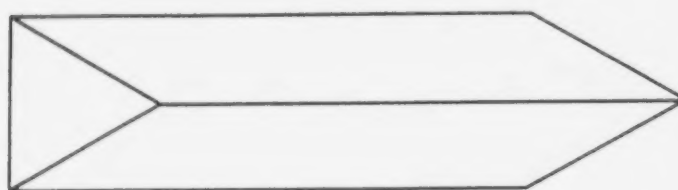


Rectangle



Rhomboid

Solids



Prism

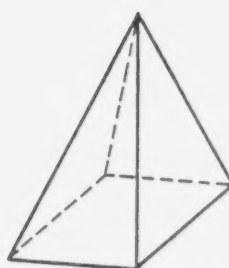
Pyramids



Right Triangular
Pyramid

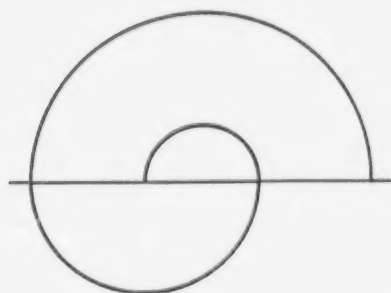


Pentagonal
Pyramid

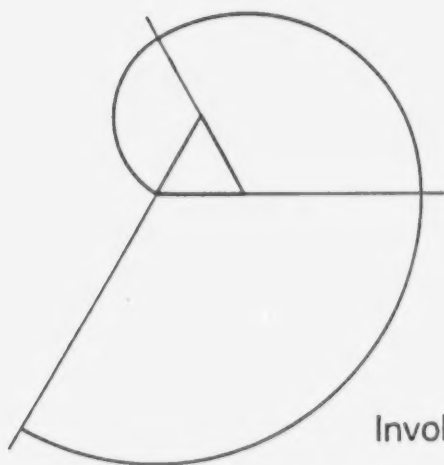


Right Square
Pyramid

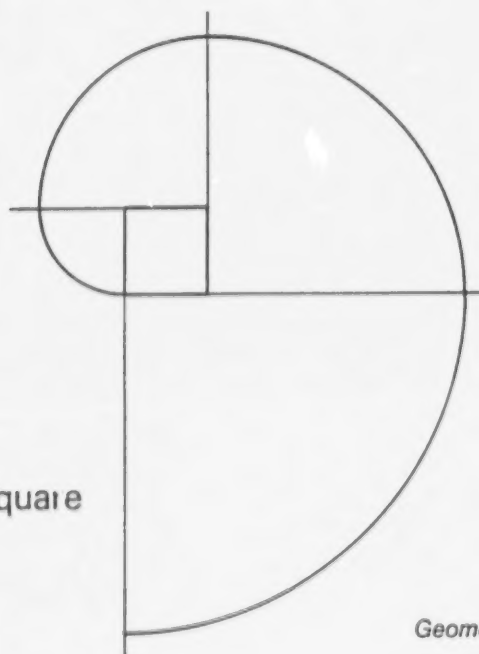
Involutes



Involute of a Line

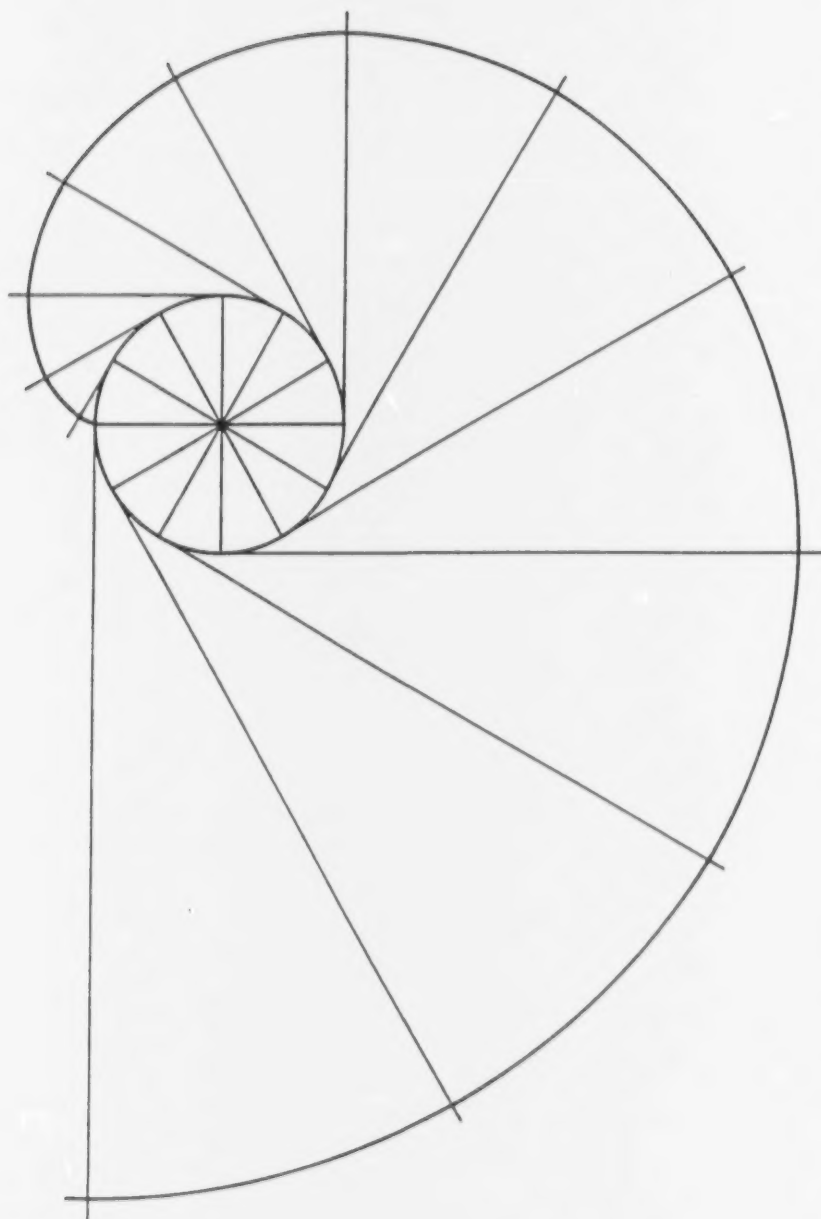


Involute of a Triangle

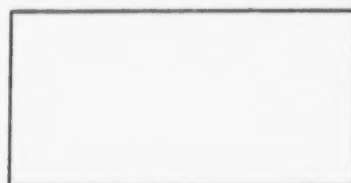


Involute of a Square

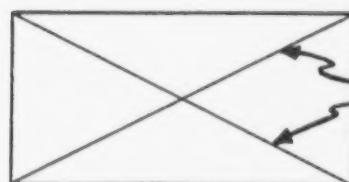
Involute of a Circle



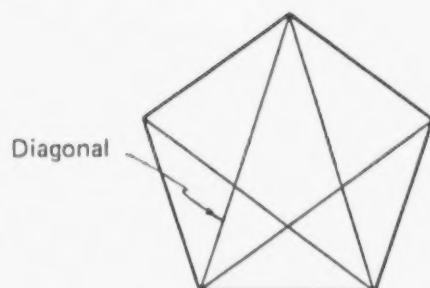
Polygons and Diagonals



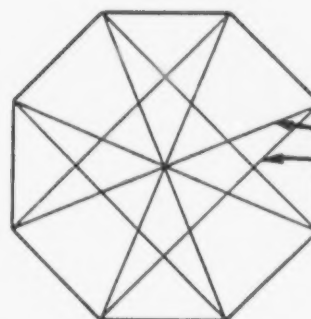
Rectangle



Rectangle

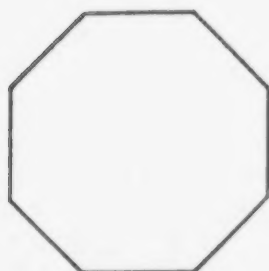


Pentagon

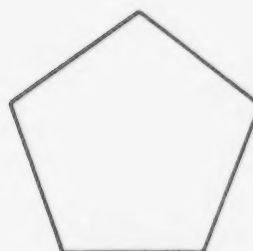


Octagon

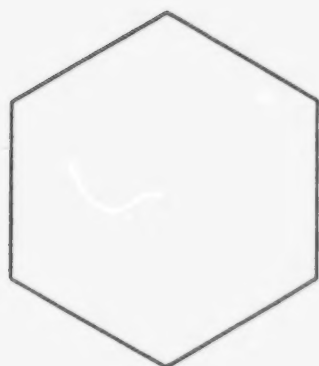
Polygons



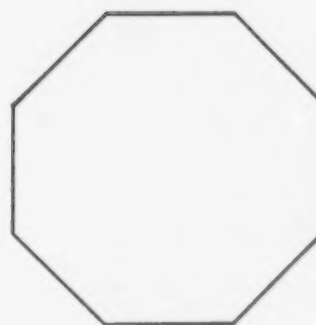
Regular Polygon



Pentagon



Hexagon



Octagon

BISECT A LINE AND AN ARC

Directions: Bisect the lines AB and arc AB below. Leave all construction lines.

Problem A:

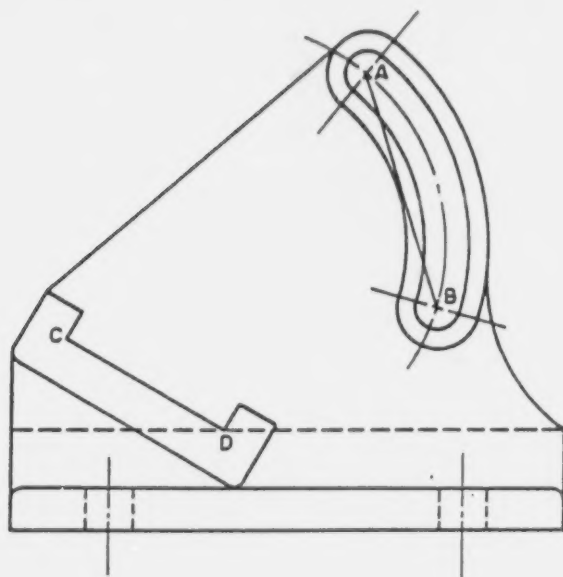


Directions: Draw construction lines lightly and do not erase them.

Problem B:

Draw 1/2" Dia. hole at intersection of perpendicular bisectors of lines AB and CD

NOTE: Draw horizontal and vertical center lines only through the hole

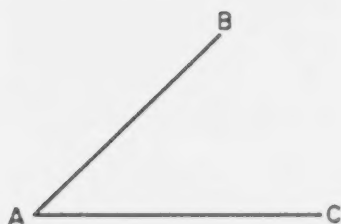
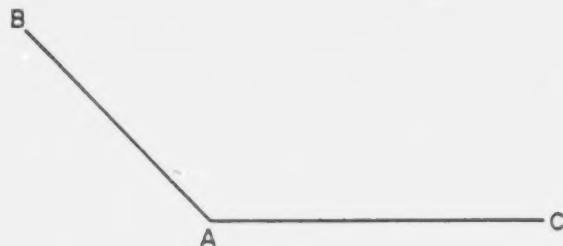


GRINDER ADJUSTING ARM

BISECT AN ANGLE

Directions: Bisect the angles below. Leave all construction lines.

Problem:

**DRAW PARALLEL LINES**

Directions: Construct a line parallel to line AB 1" below line AB. Leave all construction lines.

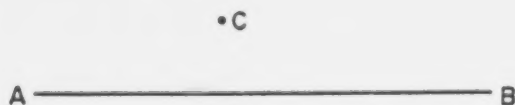
Problem:



**CONSTRUCT A PERPENDICULAR LINE
TO A LINE FROM A POINT**

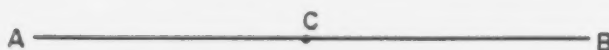
Direction: Construct a line perpendicular from point C to line AB. Leave all construction lines.

Problem:

**DRAW A LINE PERPENDICULAR THROUGH A
POINT ON A LINE**

Directions: Draw a line perpendicular through point C on line AB. Leave all construction lines.

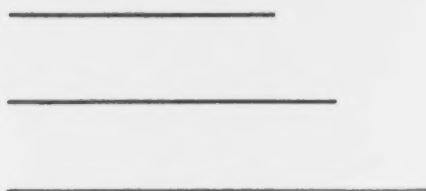
Problem:



CONSTRUCT A TRIANGLE WITH SIDES GIVEN

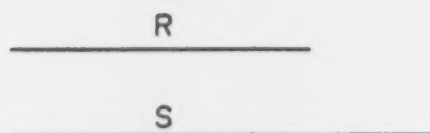
Directions: Construct a triangle using the three lines given below. Leave all construction lines.

Problem:

**CONSTRUCT A RIGHT TRIANGLE**

Directions: Construct a right triangle using the two lines given below. Leave all construction lines.

Problem:



**CONSTRUCT AN EQUILATERAL TRIANGLE
WITH ONE SIDE GIVEN**

Directions: Construct an equilateral triangle with side AB given. Use both methods and leave all construction lines.

Problem:

A ————— B

COMPASS

A ————— B

TRIANGLE

INSCRIBE A HEXAGON INSIDE A CIRCLE

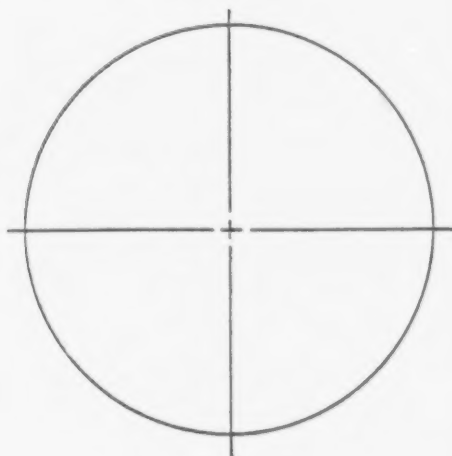
Directions: Draw a hexagon in the circle below. Leave all construction lines.

Problem:

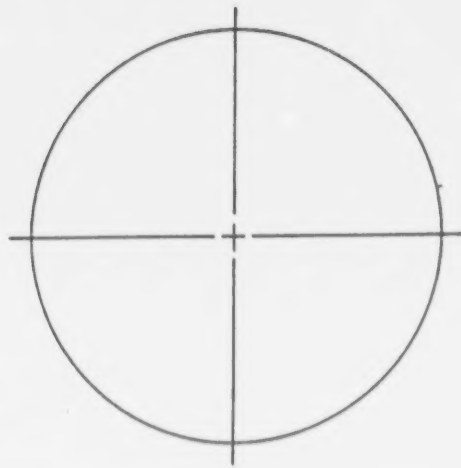
**CONSTRUCT A HEXAGON WITH THE
DISTANCE ACROSS THE FLAT SIDES GIVEN**

Directions: Construct a hexagon using this circle as the distance across flats. Leave all construction lines.

Problem A: Put flats on top and bottom



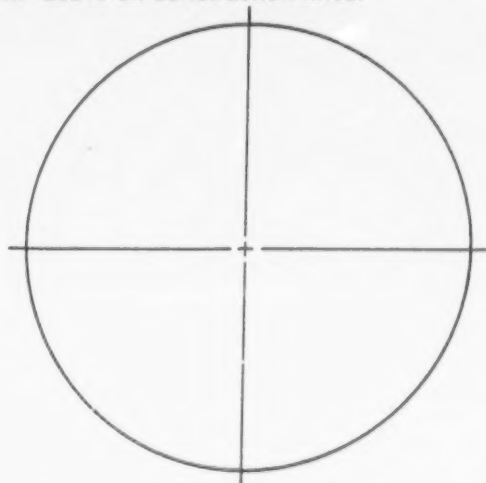
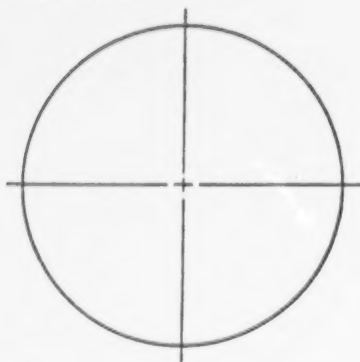
Problem B: Put flats on sides



CONSTRUCT A PENTAGON BY INSCRIBING

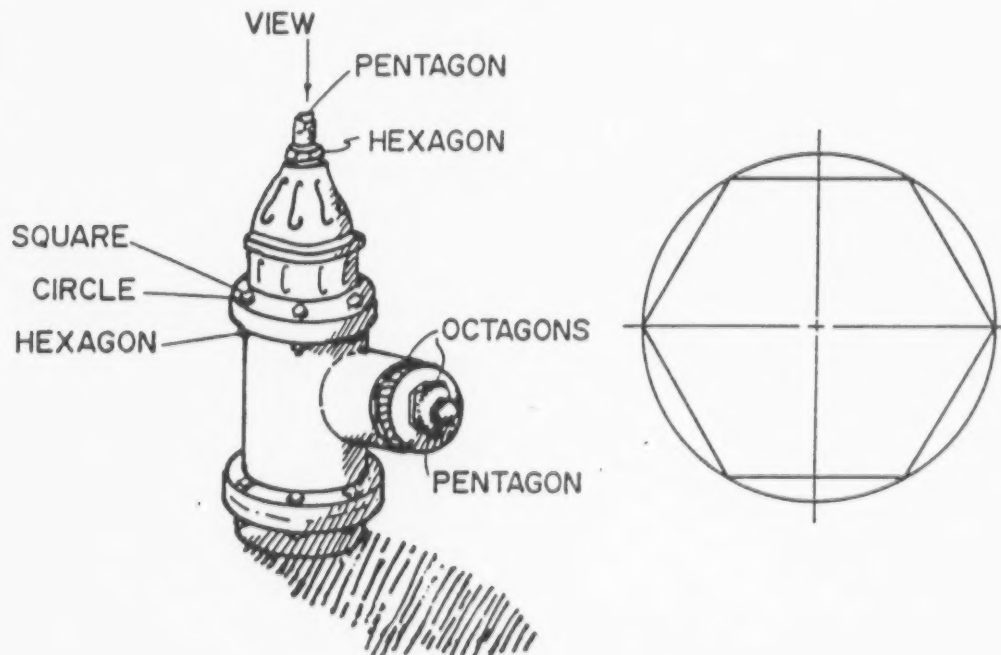
Directions: Inscribe a pentagon in the circles below. Leave all construction lines.

Problem A:



Directions: Inscribe a pentagon in a 2" circle (within hexagon) as used in the following drawing. Draw construction lines lightly and do not erase them.

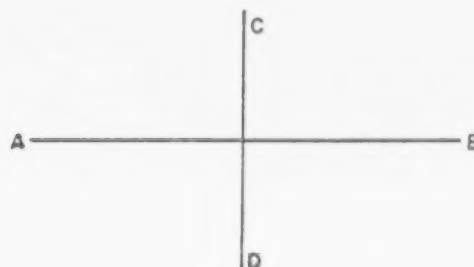
Problem B:



DRAW ELLIPSES USING THE APPROXIMATE ELLIPSE WITH COMPASS METHOD

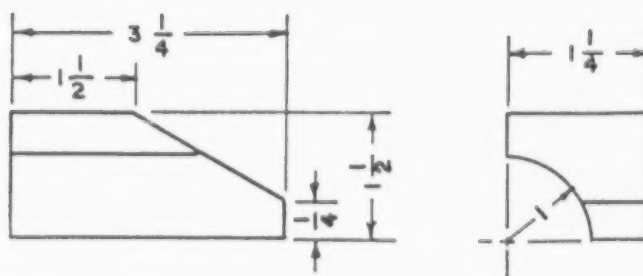
Directions: Construct an approximate ellipse of the axis lines AB and CD. Leave all construction lines.

Problem A:



Problem B:

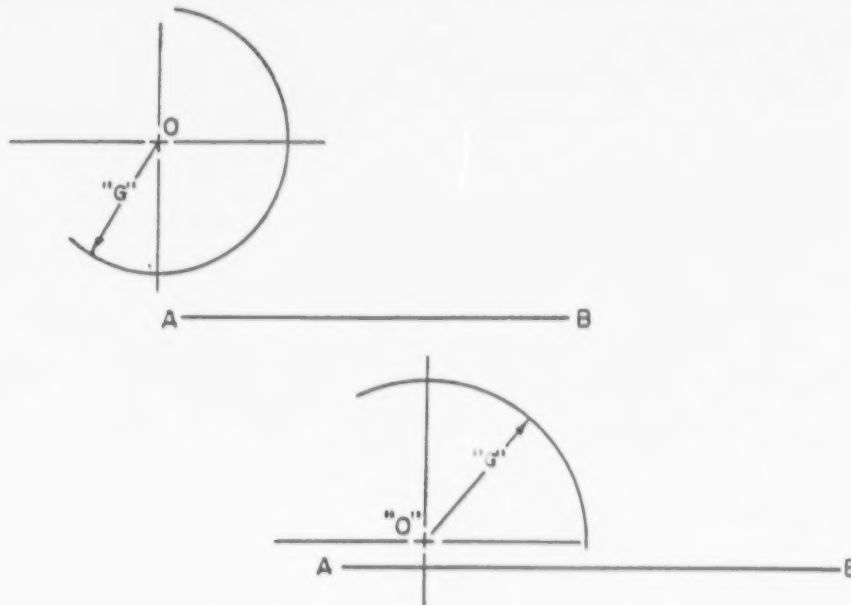
Directions: Construct three views of the following object full size on available media. Leave construction lines. Do not dimension. Leave 1" of space between views.



DRAW AN ARC TANGENT TO A STRAIGHT LINE AND AN ARC

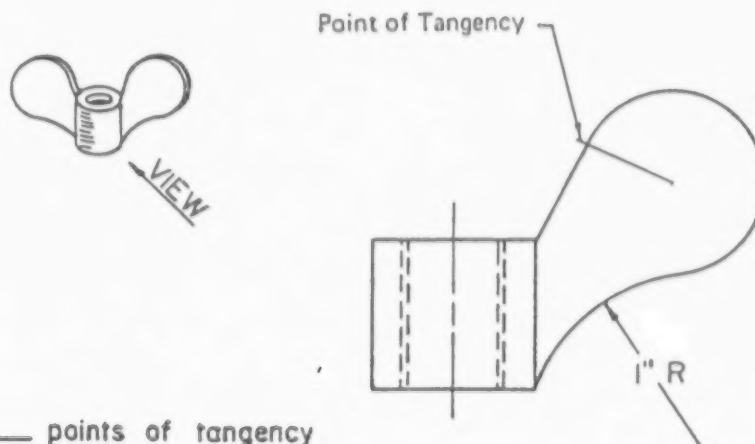
Directions: Connect line AB to arc OG with 1" R arc. Leave all construction lines.

Problem A:



Directions: Complete the drawing of a wing nut and mark all points of tangency. Draw construction lines lightly and do not erase them.

Problem B:

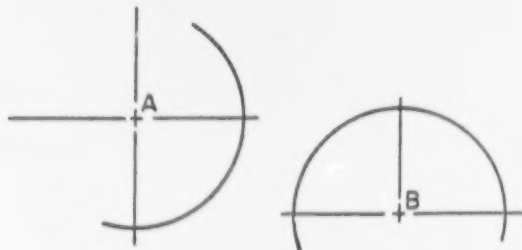


There are ____ points of tangency
on this wing nut

DRAW AN ARC TANGENT TO TWO ARCS

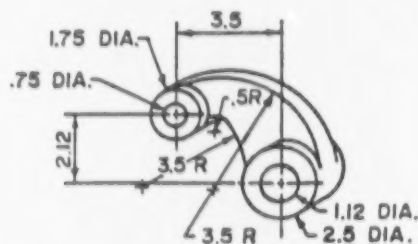
Directions: Connect the two circles with $1/2"$ diameter circle. Leave all construction lines.

Problem A:



Directions: Complete the drawing of a toggle link as shown in the following drawing. Draw on size "A" vellum using title block determined by the instructor. Mark points of tangency. Do not use arithmetic to add or subtract radii; do it graphically. Draw construction lines lightly and do not erase them.

Problem B:

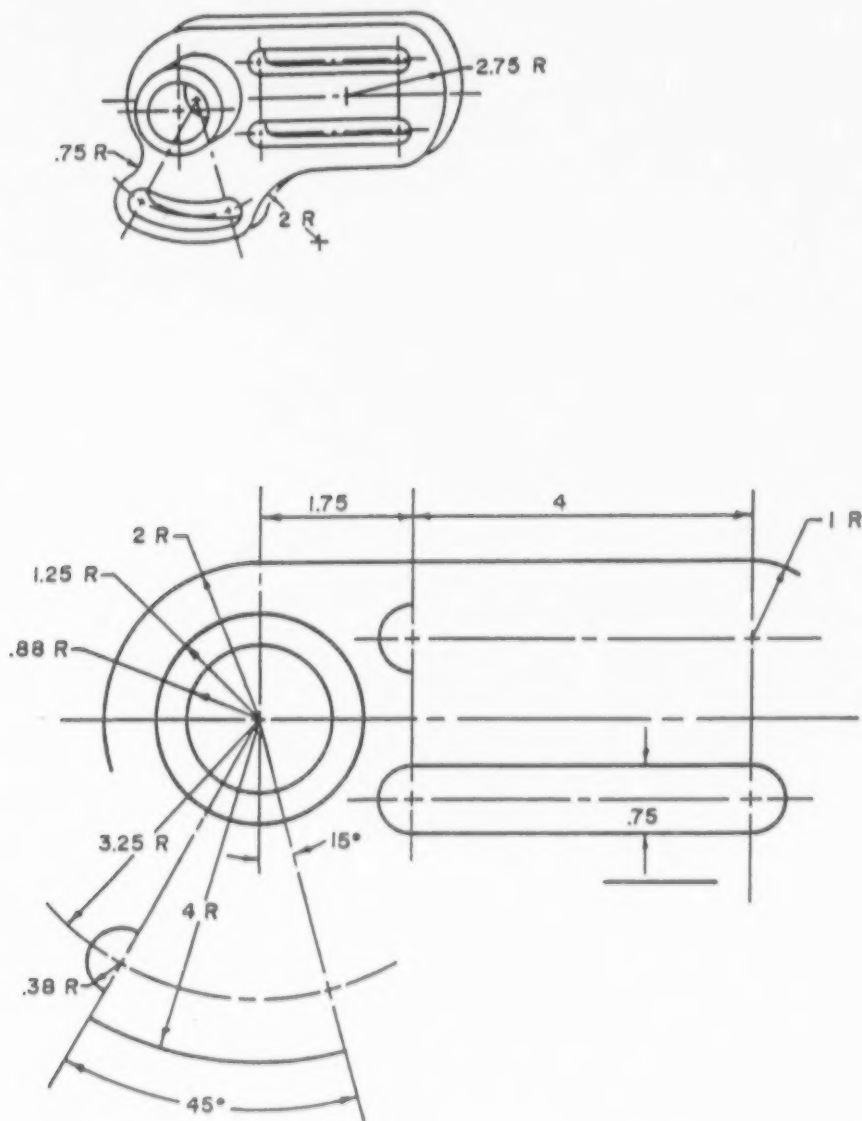


Scale: Full size on vellum

There are ____ tangency points
on this view

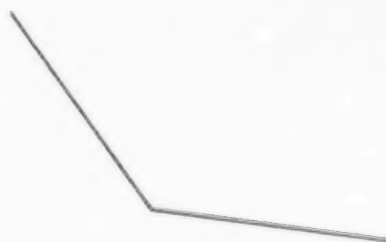
Directions: Complete the drawing of an operating arm as shown in the following drawing. Draw on size "A" vellum using title block determined by the instructor.

Problem C:



**DRAW AN ARC TANGENT TO AN ACUTE
ANGLE AND AN OBTUSE ANGLE**

Directions: Connect the sides of the angles below with a $\frac{1}{2}$ " radius arc. Leave all construction lines.



DRAW AN ARC TANGENT TO A RIGHT ANGLE

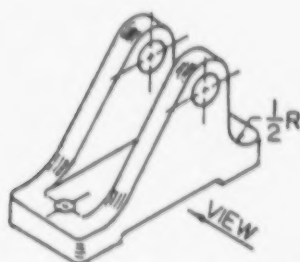
Directions: Draw a $\frac{3}{4}$ " R arc in the right angles below. Leave all construction lines.

Problem A:

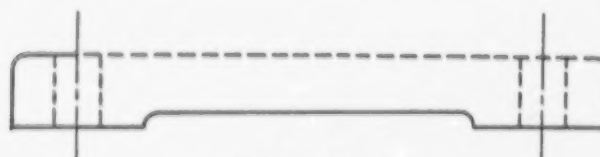


Directions: Draw arc tangents to complete the drawing as shown in the following bracket. Mark points of tangency. Draw construction lines lightly and do not erase them.

Problem B:



Center point of arc



BRACKET
Scale: Full Size

There are —
points of tangency
on this view

Geometric Constructions

211

DIVIDE A LINE INTO EQUAL PARTS

Directions: Divide line AB into seven equal divisions. Leave all construction lines.

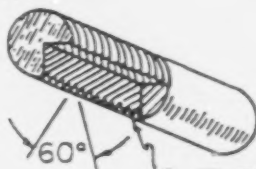
Problem A:



Directions: Divide horizontal line into five equal parts per inch starting at point A. Draw 60° Vs as shown in the following threaded rod. Draw construction lines lightly and do not erase them. Complete section lines.

Problem B:

THREADED ROD



5 THREADS PER INCH



MODULE: CONSTRUCTION TECHNIQUES

UNIT IV: GEOMETRIC CONSTRUCTIONS

UNIT TEST

Match the terms on the right with their correct definitions on the left.

- | | | |
|----------|--|-------------------|
| _____ 1. | A small dot or small cross on a drawing or in space that does not have length, height, depth, or width | a. Intersect |
| _____ 2. | A connection between two or more points | b. Point |
| _____ 3. | The shortest distance between two points | c. Vertex |
| _____ 4. | a line in which no segment is straight | d. Line |
| _____ 5. | Any part of a line | e. Perpendicular |
| _____ 6. | A flat, level, even surface such as a piece of paper lying flat on a table | ab. Curved line |
| _____ 7. | To cut across each other | ac. Plane figure |
| _____ 8. | The common point where lines or surfaces intersect | ad. Straight line |
| _____ 9. | At 90° angles to a given plane or line | ae. Line segment |

Match the terms on the right with their correct definitions on the left.

- | | | |
|-----------|--|--------------------|
| _____ 10. | Straight lines that do not meet or intersect and are an equal distance apart at all points | a. Skew lines |
| _____ 11. | Line used to extend from one view to another view | b. Edge |
| _____ 12. | Straight lines that do not intersect and are not parallel or in the same plane | c. Bisect |
| _____ 13. | To divide into two equal parts | d. Projection line |
| _____ 14. | A line straight up and down perpendicular to the horizontal plane | e. Horizontal |
| _____ 15. | Parallel to the plane of the horizon | ab. Vertical |
| _____ 16. | What appears as a line when a plane surface is perpendicular to a plane of projection | ac. Equilateral |
| _____ 17. | All sides are equal | ad. Parallel |

Match types of angles on the right with their correct descriptions on the left.

- | | | |
|-----------|---|-------------------------|
| _____ 18. | Figure formed by two intersecting lines | a. Obtuse angle |
| _____ 19. | A 90° angle | b. Right angle |
| _____ 20. | An angle less than 90° | c. Supplementary angles |
| _____ 21. | An angle greater than 90° | d. Angle |
| _____ 22. | Two angles whose sum is 90° | e. Complementary angles |
| _____ 23. | Two angles whose sum is 180° | ab. Acute angle |

Match types of triangles on the right with their correct descriptions.

- | | | |
|-----------|---|-------------------------|
| _____ 24. | A plane figure bound by three straight sides, and three interior angles which equal 180° | a. Triangle |
| _____ 25. | A triangle with three equal sides and three equal angles | b. Right triangle |
| _____ 26. | A triangle with two equal sides and two equal angles | c. Scalene triangle |
| _____ 27. | A triangle with no angles or sides equal | d. Equilateral triangle |
| _____ 28. | A triangle with one 90° angle | e. Isosceles triangle |

Match circular shapes on the right with their correct descriptions.

- | | | |
|-----------|---|------------------------|
| _____ 29. | The distance around a circle | a. Circumference |
| _____ 30. | The distance from the center point of a circle to the outside circumference | b. Arc |
| _____ 31. | The distance across a circle passing through its center point | c. Symmetrical |
| _____ 32. | A closed curve all points of which are an equal distance from the center | d. Radius |
| _____ 33. | Any portion of the circumference of a circle | e. Axis |
| _____ 34. | A round body such as a ball which has all points of its circumference an equal distance from its center | ab. Eccentric circles |
| _____ 35. | Having the same point as center | ac. Sphere |
| _____ 36. | Having different points as center, one within the other | ad. Circle |
| _____ 37. | The same on both sides of a center line | ae. Diameter |
| _____ 38. | A figure drawn within another figure so as to touch in as many places as possible | bc. Inscribed |
| _____ 39. | A figure encircled so as to touch in as many places as possible | bd. Circumscribed |
| _____ 40. | A straight line passing through the center of a geometric body upon which the geometric body rotates | be. Concentric circles |

Match circular shapes on the right with their correct descriptions on the left.

- | | | |
|-----------|--|----------------------|
| _____ 41. | Meeting a curved line or surface, touching at one and only one point, but most definitely not intersecting | a. Tangent |
| | | b. Chord |
| _____ 42. | A solid figure generated by a circle which is revolving on an axis which is eccentric to the circle | c. Sector |
| | | d. Quadrant |
| _____ 43. | A foreshortened circle having a major diameter and a minor diameter | e. Torus |
| | | ab. Semicircle |
| _____ 44. | A solid figure obtained by taking a rectangle by its edge and rotating it around to its parallel edge, making the ends parallel, and the circles equal | ac. Ellipse |
| | | ad. Cylinder |
| _____ 45. | Any straight line across a circle that does not pass through the center | ae. Circular segment |
| _____ 46. | One-half of a circle | |
| _____ 47. | Less than a semicircle | |
| _____ 48. | One-fourth of a circle | |
| _____ 49. | Less than a quadrant | |

Match four-sided shapes, cones, and special figures on the right with their correct descriptions on the left.

- | | | |
|-----------|---|--------------------|
| _____ 50. | A plane figure bound by four equal sides, and having four 90° angles | a. Helix |
| _____ 51. | A plane figure bound by parallel sides of different lengths to form opposite sides that are equal, and having four 90° angles | b. Cycloid |
| _____ 52. | A solid figure with a circle as its base, and a curved surface tapering evenly to the vertex, so that any point on the surface is in a straight line between the circumference of the base and the vertex | c. Quadrilateral |
| _____ 53. | Curves produced by a plane when it intersects a right circular cone | d. Square |
| _____ 54. | A curve generated by a point moving so that its distance from a fixed point is equal to its distance from a fixed line | e. Involute |
| _____ 55. | Generated by a point moving along and around the surface of a cone or cylinder with a uniform angular velocity about the axis, and with a uniform linear velocity in the direction of the axis | ab. Parabola |
| _____ 56. | A curve generated by a point located on the circumference of a circle as the circle rolls along a straight line | ac. Prism |
| _____ 57. | A plane figure bound by four straight sides | ad. Rectangle |
| _____ 58. | A plane figure bound by four straight sides with the opposite sides parallel | ae. Parallelogram |
| _____ 59. | A solid figure whose plane bases are parallel equal polygons and whose faces are parallelograms | bc. Cone |
| _____ 60. | A solid figure with a polygon for a base, with triangular lateral faces that intersect at a common point called a vertex | bd. Pyramid |
| _____ 61. | A curve traced by a point on a thread or string, as the thread or string unwinds from a line | be. Conic sections |

Match polygons and diagonals on the right with their correct descriptions on the left.

- | | | |
|-----------|---|--------------------|
| _____ 62. | A plane figure with more than three straight sides | a. Hexagon |
| _____ 63. | Lines connecting opposite nonsymmetrical corners of a polygon | b. Diagonals |
| _____ 64. | A plane figure with equal straight sides and equal angles; it can be circumscribed around, or inscribed in a circle | c. Octagon |
| _____ 65. | A polygon that has five equal sides and five equal angles | d. Regular polygon |
| _____ 66. | A polygon that has six equal sides and six equal angles | e. Polygon |
| _____ 67. | A polygon that has eight equal sides and eight equal angles | ab. Pentagon |

Match the names of geometric shapes on the right to the correct shapes on the left.

____ 68.



____ 69.



____ 70.



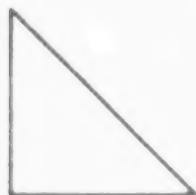
____ 71.



____ 72.



____ 73.



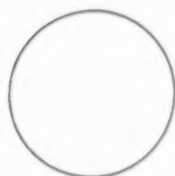
- a. Isosceles triangle
- b. Right triangle
- c. Scalene triangle
- d. Acute angle
- e. Straight angle
- ab. Obtuse angle

Match the names of geometric shapes on the right to the correct shapes on the left.

____ 74.



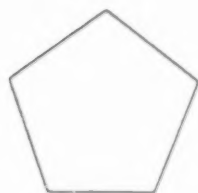
____ 75.



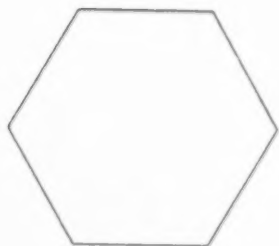
____ 76.



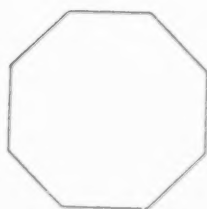
____ 77.



____ 78.



____ 79.



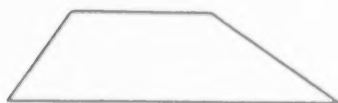
- a. Sphere
- b. Circle
- c. Octagon
- d. Equilateral triangle
- e. Hexagon
- ab. Pentagon

Match the names of the quadrilaterals on the right to the correct shapes on the left.

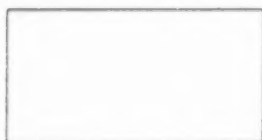
___ 80.



___ 81.



___ 82.



___ 83.



a. Trapezoid

b. Square

c. Rectangle

d. Trapezium

Match the names of the parallelograms on the right to the correct shapes on the left.

___ 84.



a. Square

b. Rhombus

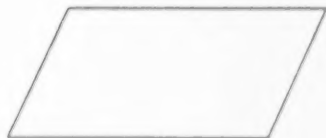
c. Rectangle

d. Rhomboid

___ 85.



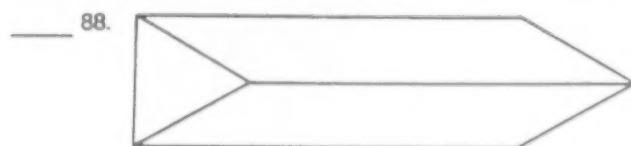
___ 86.



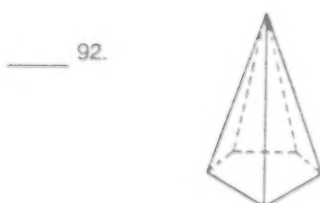
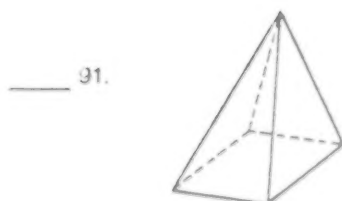
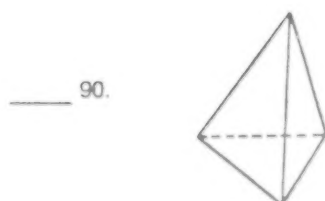
___ 87.



Match the names of the geometric shapes on the right with the correct shapes on the left.



- a. Torus
- b. Prism Pyramids
- c. Pentagonal
- d. Right square
- e. Right triangular



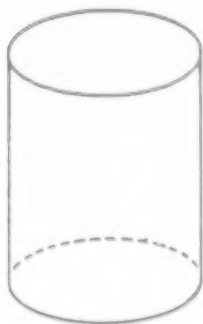
Match the names of the geometric shapes on the right to the correct shapes on the left.

___ 93.

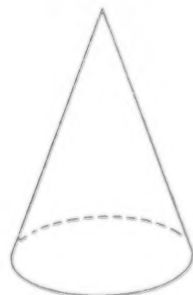


- a. Cone
- b. Ellipse
- c. Parabola
- d. Cylinder

___ 94.



___ 95.

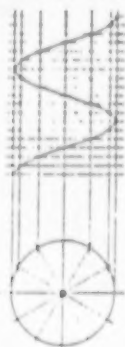


___ 96.



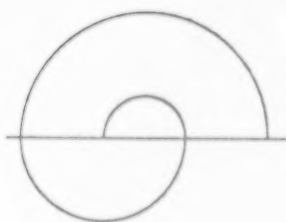
Match the names of the geometric shapes on the right to the correct shapes on the left.

___ 97.



- a. Cycloid
- b. Helix
- c. Involute of a square
- d. Involute of a circle
- e. Involute of a triangle
- ab. Involute of a line

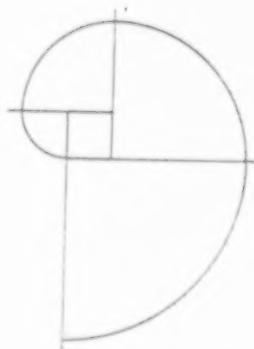
___ 98.



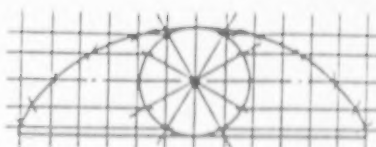
___ 101.



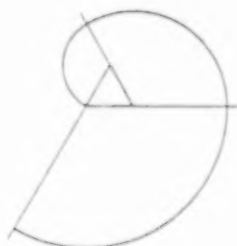
___ 99.



___ 102.



___ 100.



Match geometric terms on the right with their correct symbols on the left.

___ 103. $\angle$

___ 104. R

___ 105. $\perp$

___ 106. $\parallel$

___ 107. $\emptyset$

___ 108. $<$

___ 109. $\angle s$

___ 110. $>$

a. Perpendicular

b. Parallel

c. Angle

d. Angles

e. Less than

ab. Greater than

ac. Diameter

ad. Radius

ANSWERS TO UNIT IV TEST (D-1)

- | | | | |
|-----|----|-----|----|
| 1. | b | 25. | d |
| 2. | d | 26. | e |
| 3. | ad | 27. | c |
| 4. | ab | 28. | b |
| 5. | ae | 29. | a |
| 6. | ac | 30. | d |
| 7. | a | 31. | ae |
| 8. | c | 32. | ad |
| 9. | e | 33. | b |
| 10. | ad | 34. | ac |
| 11. | d | 35. | be |
| 12. | a | 36. | ab |
| 13. | c | 37. | c |
| 14. | ab | 38. | bc |
| 15. | e | 39. | bd |
| 16. | b | 40. | e |
| 17. | ac | 41. | a |
| 18. | d | 42. | e |
| 19. | b | 43. | ac |
| 20. | ab | 44. | ad |
| 21. | a | 45. | b |
| 22. | e | 46. | ab |
| 23. | c | 47. | e |
| 24. | a | 48. | d |

49. c
50. d
51. ad
52. bc
53. be
54. ab
55. a
56. b
57. c
58. ae
59. ac
60. bd
61. e
62. e
63. b
64. d
65. ab
66. a
67. c
68. e
69. d
70. ab
71. a
72. c
73. b
74. d
75. b
76. a

77. ab
78. e
79. c
80. d
81. a
82. c
83. b
84. a
85. b
86. d
87. c
88. b
89. a
90. e
91. d
92. c
93. b
94. d
95. a
96. c
97. b
98. ab
99. c
100. e
101. d
102. a
103. e
104. ad

- 105. a
- 106. b
- 107. ac
- 108. c
- 109. d
- 110. ab